CLASS 11 MATHEMATICS — FORMULA SHEET

Chapter 1 : Sets (NCERT)

1.1 Sets — Basic Definitions

Term	Definition / Notation
Set	A well-defined collection of distinct objects; denoted by capital letters A, B, C
Element	$a \in A$ means 'a belongs to A' ; $a \notin A$ means 'a does not belong to A'
Roster (tabular) form	List all elements in braces: A = {1, 2, 3, 4}
Set-builder form	State a common property: A = {x : x is a natural number, x < 5}
Standard number sets	N (naturals), Z (integers), Q (rationals), R (reals), W (whole), T (irrationals)
Cardinal number n(A)	Number of distinct elements in a finite set A

1.2 Types of Sets

Type	Definition / Example
Empty (null/void) set	Has no element ; denoted φ or { } ; e.g. $\{x : x^2 = -1, x \in R\}$
Singleton set	Exactly one element ; e.g. {0}
Finite set	Countable number of elements
Infinite set	Uncountable / endless elements ; e.g. N, Z, R
Equal sets	A = B if they have exactly the same elements
Equivalent sets	Same number of elements: n(A) = n(B)
Subset ($A \subseteq B$)	Every element of A is in B ; φ is a subset of every set
Proper subset ($A \subset B$)	$A \subseteq B$ but $A \neq B$
Superset ($B \supseteq A$)	B contains A
Universal set (U)	The set containing all objects under consideration

1.3 Power Set & Intervals

Concept	Detail / Formula
Power set P(A)	Set of all subsets of A
Number of subsets	If n(A) = n, then number of subsets = 2^n
Number of proper subsets	$= 2^n - 1$
Number of non-empty subsets	$= 2^n - 1$
Open interval (a, b)	$\{x : a < x < b\}$ — endpoints excluded
Closed interval [a, b]	$\{x : a \le x \le b\}$ — endpoints included
Half-open [a, b) / (a, b]	One endpoint included, the other excluded

1.4 Operations on Sets

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Operation	Definition
Union ($A \cup B$)	$\{x : x \in A \text{ OR } x \in B\}$ — all elements of both
Intersection ($A \cap B$)	$\{x : x \in A \text{ AND } x \in B\}$ — common elements
Difference ($A - B$)	$\{x : x \in A \text{ and } x \notin B\}$ — in A but not in B
Complement (A' or A^c)	$U - A = \{x : x \in U \text{ and } x \notin A\}$
Disjoint sets	$A \cap B = \varphi$ (no common element)
Symmetric difference ($A \Delta B$)	$(A - B) \cup (B - A)$

1.5 Algebra of Sets (Laws)

Law	Statement
Commutative	$A \cup B = B \cup A$; $A \cap B = B \cap A$
Associative	$(A \cup B) \cup C = A \cup (B \cup C)$; similarly for $\cap$
Distributive	$A \cap (B \cup C) = (A \cap B) \cup (A \cap C)$; $A \cup (B \cap C) = (A \cup B) \cap (A \cup C)$
Identity	$A \cup \varphi = A$; $A \cap U = A$
Idempotent	$A \cup A = A$; $A \cap A = A$
Complement laws	$A \cup A' = U$; $A \cap A' = \varphi$; $(A')' = A$
De Morgan's laws	$(A \cup B)' = A' \cap B'$; $(A \cap B)' = A' \cup B'$
U and φ	$U' = \varphi$; $\varphi' = U$

1.6 Cardinality (Counting) Formulas

Formula	Expression
Two sets (union)	$n(A \cup B) = n(A) + n(B) - n(A \cap B)$
Disjoint sets	$n(A \cup B) = n(A) + n(B)$ (when $A \cap B = \varphi$)
Three sets	$n(A \cup B \cup C) = n(A) + n(B) + n(C) - n(A \cap B) - n(B \cap C) - n(C \cap A) + n(A \cap B \cap C)$
Only A (of two)	$n(A \text{ only}) = n(A) - n(A \cap B)$
Complement count	$n(A') = n(U) - n(A)$
Neither A nor B	$n((A \cup B)') = n(U) - n(A \cup B)$

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Subset count	n elements → 2^n subsets, $2^n - 1$ proper subsets, $2^n - 1$ non-empty subsets.
Empty set is special	φ is a subset of EVERY set ; $n(\varphi) = 0$; $\varphi \neq \{0\} \neq \{\varphi\}$.
Union vs Intersection	Union = OR (everything) ; Intersection = AND (common only).
De Morgan	Complement of union = intersection of complements (and vice versa).
Two-set formula	$n(A \cup B) = n(A) + n(B) - n(A \cap B)$. Always subtract the overlap once.
Equal vs Equivalent	Equal = same elements ; Equivalent = same NUMBER of elements.

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Interval brackets	Round ( ) excludes endpoint ; square [ ] includes it.
Venn diagrams	Best tool for 2-3 set word problems — fill the innermost region first.

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Chapter 2 : Relations and Functions (NCERT)

2.1 Ordered Pairs & Cartesian Product

Concept	Definition / Formula
Ordered pair	(a, b) ; order matters → (a, b) ≠ (b, a) unless a = b
Equality of pairs	(a, b) = (c, d) ⇔ a = c and b = d
Cartesian product A × B	{(a, b) : a ∈ A, b ∈ B}
Cardinality	n(A × B) = n(A) × n(B)
A × B vs B × A	A × B ≠ B × A (unless A = B or one is empty)
A × A × A	Set of ordered triplets (a, b, c)
If n(A) = p, n(B) = q	n(A × B) = pq ; number of relations = 2^{pq}

2.2 Relations

Concept	Definition
Relation R (from A to B)	A subset of A × B ; R ⊆ A × B
Domain of R	Set of all first elements (a) of the ordered pairs in R
Range of R	Set of all second elements (b) of the ordered pairs in R
Codomain of R	The set B (range ⊆ codomain)
Number of relations	If n(A) = p, n(B) = q → total relations = 2^{pq}
Identity relation	R = {(a, a) : a ∈ A}
Empty & universal relation	φ (no pair) and A × A (all pairs)

2.3 Functions (Mappings)

Concept	Definition
Function f : A → B	A relation where EVERY element of A has EXACTLY ONE image in B
Image & pre-image	If f(a) = b, then b is the image of a, and a is a pre-image of b
Domain	Set A (all inputs)
Codomain	Set B (all possible outputs)
Range	Set of actual outputs {f(a) : a ∈ A} ; Range ⊆ Codomain
Real function	Domain and range are subsets of R
Vertical line test	A graph is a function if every vertical line cuts it at most once

2.4 Standard Real Functions

Function	Definition	Domain & Range
Identity	f(x) = x	Domain R, Range R

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Function	Definition	Domain & Range
Constant	f(x) = c	Domain R, Range {c}
Polynomial	$f(x) = a_0 + a_1x + \dots + a_nx^n$	Domain R
Modulus	f(x) = |x|	Domain R, Range [0, ∞)
Signum	f(x) = 1 (x>0), 0 (x=0), −1 (x<0)	Range {−1, 0, 1}
Greatest integer [x]	Greatest integer ≤ x	Domain R, Range Z
Reciprocal	f(x) = 1/x	Domain R−{0}, Range R−{0}
Square root	f(x) = √x	Domain [0, ∞), Range [0, ∞)
Exponential	$f(x) = a^x$, a > 0	Domain R, Range (0, ∞)
Logarithmic	$f(x) = \log_a x$, a>0, a≠1	Domain (0, ∞), Range R

2.5 Algebra of Real Functions

Operation	Definition
Sum	(f + g)(x) = f(x) + g(x)
Difference	(f − g)(x) = f(x) − g(x)
Product	(f g)(x) = f(x) · g(x)
Scalar multiple	(c f)(x) = c · f(x)
Quotient	(f/g)(x) = f(x) ÷ g(x), provided g(x) ≠ 0
Domain of combination	Intersection of domains of f and g (exclude g(x)=0 for quotient)

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2.6 Finding Domain & Range — Quick Rules

Form of f(x)	Domain Rule
Polynomial	All real numbers, R
1 ÷ g(x)	All x except where g(x) = 0
√(g(x))	g(x) ≥ 0
1 ÷ √(g(x))	g(x) > 0 (strictly)
log(g(x))	g(x) > 0
Range tip	Express x in terms of y, or analyse min/max of f(x)

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Counting	n(A×B) = n(A)·n(B) ; number of relations = 2 raised to (pq) — that's a LOT for big sets.
Function rule	Every input ONE output. Same x can't go to two different y's.
Domain detectives	Denominator ≠ 0 ; inside √ must be ≥ 0 ; inside log must be > 0.
Vertical line test	Function ⇔ no vertical line meets the graph more than once.
|x| range	Modulus is always ≥ 0, so range of |x| is [0, ∞).

Greatest integer	$[2.7] = 2$, $[-2.3] = -3$ (goes DOWN to the lower integer).
Range ⊆ Codomain	Range is what actually comes out; codomain is what could come out.
exp & log	They are inverses: domain of one = range of the other.

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Chapter 3 : Trigonometric Functions (NCERT)

3.1 Angles & Measurement

Concept	Formula
Radian–degree relation	π radian = 180° ; 1 radian = 57°16′ approx
Degree to radian	radian = $(\pi/180) \times$ degree
Radian to degree	degree = $(180/\pi) \times$ radian
Arc length	$l = r\,\theta$ (θ in radians)
Area of sector	$A = \frac{1}{2} r^2 \theta = \frac{1}{2} l\, r$
Angular relation	$\theta = l / r$

3.2 Trigonometric Ratios & Standard Values

Angle	sin	cos	tan
0°	0	1	0
30° ($\pi/6$)	1/2	$\sqrt{3}/2$	$1/\sqrt{3}$
45° ($\pi/4$)	$1/\sqrt{2}$	$1/\sqrt{2}$	1
60° ($\pi/3$)	$\sqrt{3}/2$	1/2	$\sqrt{3}$
90° ($\pi/2$)	1	0	not defined
180° (π)	0	−1	0
270° ($3\pi/2$)	−1	0	not defined
360° (2π)	0	1	0

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3.3 Fundamental Identities & Reciprocals

Identity	Formula
Reciprocals	$\operatorname{cosec}\theta = 1/\sin\theta$; $\sec\theta = 1/\cos\theta$; $\cot\theta = 1/\tan\theta$
Quotient	$\tan\theta = \sin\theta/\cos\theta$; $\cot\theta = \cos\theta/\sin\theta$
Pythagorean 1	$\sin^2\theta + \cos^2\theta = 1$
Pythagorean 2	$1 + \tan^2\theta = \sec^2\theta$
Pythagorean 3	$1 + \cot^2\theta = \operatorname{cosec}^2\theta$
Range of sin & cos	$-1 \le \sin\theta \le 1$; $-1 \le \cos\theta \le 1$

3.4 Signs & Allied (Related) Angles

Concept	Rule
ASTC rule (quadrants I-IV)	I: All +ve ; II: Sin +ve ; III: Tan +ve ; IV: Cos +ve
Even/odd (negative angle)	$\sin(-\theta) = -\sin\theta$; $\cos(-\theta) = \cos\theta$; $\tan(-\theta) = -\tan\theta$

Concept	Rule
90° ± θ (co-ratios flip)	sin(90°−θ) = cos θ ; cos(90°−θ) = sin θ ; tan(90°−θ) = cot θ
180° ± θ (no flip)	sin(180°−θ) = sin θ ; cos(180°−θ) = −cos θ
360° ± θ / periodicity	sin(2π + θ) = sin θ etc. (period 2π for sin, cos)
Period of functions	sin, cos, sec, cosec → 2π ; tan, cot → π

3.5 Sum & Difference Formulas

Formula	Expression
sin(A ± B)	sin A cos B ± cos A sin B
cos(A ± B)	cos A cos B ∓ sin A sin B
tan(A ± B)	(tan A ± tan B) ÷ (1 ∓ tan A tan B)
cot(A ± B)	(cot A cot B ∓ 1) ÷ (cot B ± cot A)
2 sin A cos B	sin(A+B) + sin(A−B)
2 cos A sin B	sin(A+B) − sin(A−B)
2 cos A cos B	cos(A+B) + cos(A−B)
2 sin A sin B	cos(A−B) − cos(A+B)

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3.6 Sum-to-Product (C–D) Formulas

Formula	Expression
sin C + sin D	2 sin((C+D)/2) cos((C−D)/2)
sin C − sin D	2 cos((C+D)/2) sin((C−D)/2)
cos C + cos D	2 cos((C+D)/2) cos((C−D)/2)
cos C − cos D	−2 sin((C+D)/2) sin((C−D)/2)

3.7 Multiple & Sub-Multiple Angle Formulas

Formula	Expression
sin 2A	2 sin A cos A = 2 tan A ÷ (1 + $\tan^2$A)
cos 2A	$\cos^2$A − $\sin^2$A = 1 − 2$\sin^2$A = 2$\cos^2$A − 1 = (1−$\tan^2$A)/(1+$\tan^2$A)
tan 2A	2 tan A ÷ (1 − $\tan^2$A)
sin 3A	3 sin A − 4 $\sin^3$A
cos 3A	4 $\cos^3$A − 3 cos A
tan 3A	(3 tan A − $\tan^3$A) ÷ (1 − 3 $\tan^2$A)
Half-angle: $\sin^2$(A/2)	(1 − cos A) ÷ 2
Half-angle: $\cos^2$(A/2)	(1 + cos A) ÷ 2

3.8 Trigonometric Equations (General Solutions)

Equation	General Solution
$\sin\theta = 0$	$\theta = n\pi$, $n \in Z$
$\cos\theta = 0$	$\theta = (2n+1)\pi/2$, $n \in Z$
$\tan\theta = 0$	$\theta = n\pi$, $n \in Z$
$\sin\theta = \sin\alpha$	$\theta = n\pi + (-1)^n \alpha$
$\cos\theta = \cos\alpha$	$\theta = 2n\pi \pm \alpha$
$\tan\theta = \tan\alpha$	$\theta = n\pi + \alpha$
$\sin^2\theta = \sin^2\alpha$ (etc.)	$\theta = n\pi \pm \alpha$

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ASTC	'All Silver Tea Cups' → Quadrant I All, II Sin, III Tan, IV Cos are positive.
Standard values	sin: 0, ½, $1/\sqrt{2}$, $\sqrt{3}/2$, 1 for 0-30-45-60-90 ; cos is the reverse order.
Periods	sin, cos, sec, cosec → 2π ; tan, cot → π.
sin(A+B)	'Sin = sin cos + cos sin' ; cos(A+B) = 'cos cos − sin sin' (sign flips for cos).
cos 2A trio	Three forms: $1-2\sin^2A$, $2\cos^2A-1$, $\cos^2A-\sin^2A$ — pick what's useful.
3A formulas	$\sin 3A = 3\sin A - 4\sin^3 A$; $\cos 3A = 4\cos^3 A - 3\cos A$ (note the swap of 3 & 4).
General solution	sin → $n\pi+(-1)^n\alpha$; cos → $2n\pi\pm\alpha$; tan → $n\pi+\alpha$.
Co-functions at 90°	$90°\pm\theta$ turns sin↔cos, tan↔cot, sec↔cosec.

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Chapter 4 : Complex Numbers and Quadratic Equations (NCERT)

4.1 Complex Numbers — Basics

Concept	Definition / Formula
Imaginary unit	$i = \sqrt{(-1)}$; $i^2 = -1$
Complex number	$z = a + ib$; $a = Re(z)$ (real part), $b = Im(z)$ (imaginary part)
Purely real / imaginary	$b = 0 \rightarrow$ real ; $a = 0 \rightarrow$ purely imaginary
Equality	$a + ib = c + id \Leftrightarrow a = c$ and $b = d$
Powers of i	$i^1 = i$, $i^2 = -1$, $i^3 = -i$, $i^4 = 1$ (cycle repeats every 4)
i^n rule	Divide n by 4; use the remainder ($0\rightarrow1$, $1\rightarrow i$, $2\rightarrow-1$, $3\rightarrow-i$)

4.2 Algebra of Complex Numbers

Operation	Formula
Addition	$(a+ib) + (c+id) = (a+c) + i(b+d)$
Subtraction	$(a+ib) - (c+id) = (a-c) + i(b-d)$
Multiplication	$(a+ib)(c+id) = (ac - bd) + i(ad + bc)$
Conjugate of z	$\bar{z} = a - ib$ (changes sign of imaginary part)
Division	$z_1/z_2 = (z_1 \times \bar{z}_2) \div \lvert z_2\rvert^2$ (multiply by conjugate)
Reciprocal	$1/z = \bar{z} \div \lvert z\rvert^2 = (a - ib) \div (a^2 + b^2)$

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4.3 Modulus & Conjugate Properties

Property	Formula
Modulus	$\lvert z\rvert = \sqrt{(a^2 + b^2)}$
Modulus of product	$\lvert z_1 z_2\rvert = \lvert z_1\rvert \lvert z_2\rvert$
Modulus of quotient	$\lvert z_1/z_2\rvert = \lvert z_1\rvert \div \lvert z_2\rvert$
z times conjugate	$z \cdot \bar{z} = \lvert z\rvert^2 = a^2 + b^2$
Conjugate of sum/product	$\overline{(z_1 \pm z_2)} = \bar{z}_1 \pm \bar{z}_2$; $\overline{(z_1 z_2)} = \bar{z}_1 \bar{z}_2$
Conjugate of conjugate	$\overline{(\bar{z})} = z$
Real & imaginary parts	$Re(z) = (z + \bar{z})/2$; $Im(z) = (z - \bar{z})/2i$
$\lvert z\rvert = \lvert\bar{z}\rvert = \lvert -z\rvert$	Modulus unaffected by conjugation or sign

4.4 Polar (Modulus–Argument) Form

Concept	Formula
Polar form	$z = r(\cos\theta + i \sin\theta)$, where $r = \lvert z\rvert$
Modulus r	$r = \sqrt{(a^2 + b^2)}$

Concept	Formula
Argument (amplitude) θ	$\tan\theta = b/a$; θ measured from positive real axis
Principal argument	$-\pi < \theta \le \pi$
Euler form	$z = r\,e^{i\theta}$ ($\cos\theta + i\sin\theta = e^{i\theta}$)
Multiplication (polar)	$z_1z_2 = r_1r_2\,[\cos(\theta_1+\theta_2) + i\sin(\theta_1+\theta_2)]$
Division (polar)	$z_1/z_2 = (r_1/r_2)[\cos(\theta_1-\theta_2) + i\sin(\theta_1-\theta_2)]$

4.5 Quadratic Equations & Roots

Concept	Formula
Standard form	$ax^2 + bx + c = 0$, $a \neq 0$
Quadratic formula	$x = [-b \pm \sqrt{(b^2 - 4ac)}] \div 2a$
Discriminant	$D = b^2 - 4ac$
Roots in complex case	If $D < 0$: $x = [-b \pm i\sqrt{(4ac - b^2)}] \div 2a$
Sum of roots	$\alpha + \beta = -b/a$
Product of roots	$\alpha\,\beta = c/a$
Form an equation from roots	$x^2 - (\text{sum})x + (\text{product}) = 0$

4.6 Nature of Roots (Discriminant Test)

Discriminant $D = b^2 - 4ac$	Nature of Roots
$D > 0$ (perfect square)	Real, rational, and distinct
$D > 0$ (not perfect square)	Real, irrational, distinct (conjugate surds)
$D = 0$	Real and equal (repeated root $x = -b/2a$)
$D < 0$	Imaginary (complex conjugate roots)
Complex roots occur in pairs	If $a+ib$ is a root, so is $a-ib$ (for real coefficients)

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Powers of i	Cycle of 4: $i, -1, -i, 1$. Divide the power by 4 and use the remainder.
Division trick	To divide complex numbers, multiply top & bottom by the conjugate of the denominator.
$z\cdot\bar{z} = \lvert z\rvert^2$	Always real and non-negative. Handy for rationalising.
Modulus	$\lvert z\rvert = \sqrt{(a^2 + b^2)}$; $\lvert z\rvert = \lvert\bar{z}\rvert = \lvert -z\rvert$.
Sum & product	$\alpha+\beta = -b/a$, $\alpha\beta = c/a$. Build equation: $x^2 - (\text{sum})x + (\text{product}) = 0$.
Discriminant	$D>0$ real distinct, $D=0$ real equal, $D<0$ complex conjugate pair.
Complex roots	For real coefficients, complex roots ALWAYS come in conjugate pairs.
Polar multiply	Multiply moduli, ADD arguments ; divide moduli, SUBTRACT arguments.

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Chapter 4 : Complex Numbers and Quadratic Equations (NCERT)

4.1 Complex Numbers — Basics

Concept	Definition / Formula
Imaginary unit	$i = \sqrt{(-1)}$; $i^2 = -1$
Complex number	$z = a + ib$; $a = \text{Re}(z)$ (real part), $b = \text{Im}(z)$ (imaginary part)
Purely real / imaginary	$b = 0 \rightarrow$ real ; $a = 0 \rightarrow$ purely imaginary
Equality	$a + ib = c + id \Leftrightarrow a = c$ and $b = d$
Powers of i	$i^1 = i$, $i^2 = -1$, $i^3 = -i$, $i^4 = 1$ (cycle repeats every 4)
i^n rule	Divide n by 4; use the remainder ($0\rightarrow1$, $1\rightarrow i$, $2\rightarrow-1$, $3\rightarrow-i$)

4.2 Algebra of Complex Numbers

Operation	Formula
Addition	$(a+ib) + (c+id) = (a+c) + i(b+d)$
Subtraction	$(a+ib) - (c+id) = (a-c) + i(b-d)$
Multiplication	$(a+ib)(c+id) = (ac - bd) + i(ad + bc)$
Conjugate of z	$\bar{z} = a - ib$ (changes sign of imaginary part)
Division	$z_1/z_2 = (z_1 \times \bar{z}_2) \div \lvert z_2\rvert^2$ (multiply by conjugate)
Reciprocal	$1/z = \bar{z} \div \lvert z\rvert^2 = (a - ib) \div (a^2 + b^2)$

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Property	Formula
Modulus	$\lvert z\rvert = \sqrt{(a^2 + b^2)}$
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Modulus of quotient	$\lvert z_1/z_2\rvert = \lvert z_1\rvert \div \lvert z_2\rvert$
z times conjugate	$z \cdot \bar{z} = \lvert z\rvert^2 = a^2 + b^2$
Conjugate of sum/product	$\overline{(z_1 \pm z_2)} = \bar{z}_1 \pm \bar{z}_2$; $\overline{(z_1z_2)} = \bar{z}_1 \bar{z}_2$
Conjugate of conjugate	$\overline{(\bar{z})} = z$
Real & imaginary parts	$\text{Re}(z) = (z + \bar{z})/2$; $\text{Im}(z) = (z - \bar{z})/2i$
$\lvert z\rvert = \lvert \bar{z}\rvert = \lvert -z\rvert$	Modulus unaffected by conjugation or sign

4.4 Polar (Modulus–Argument) Form

Concept	Formula
Polar form	$z = r(\cos\theta + i \sin\theta)$, where $r = \lvert z\rvert$
Modulus r	$r = \sqrt{(a^2 + b^2)}$

Concept	Formula
Argument (amplitude) θ	$\tan\theta = b/a$; θ measured from positive real axis
Principal argument	$-\pi < \theta \le \pi$
Euler form	$z = r\,e^{i\theta}$ ($\cos\theta + i\sin\theta = e^{i\theta}$)
Multiplication (polar)	$z_1z_2 = r_1r_2[\cos(\theta_1+\theta_2) + i\sin(\theta_1+\theta_2)]$
Division (polar)	$z_1/z_2 = (r_1/r_2)[\cos(\theta_1-\theta_2) + i\sin(\theta_1-\theta_2)]$

4.5 Quadratic Equations & Roots

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Discriminant	$D = b^2 - 4ac$
Roots in complex case	If $D < 0$: $x = [-b \pm i\sqrt{(4ac - b^2)}] \div 2a$
Sum of roots	$\alpha + \beta = -b/a$
Product of roots	$\alpha\beta = c/a$
Form an equation from roots	$x^2 - (\text{sum})x + (\text{product}) = 0$

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Discriminant $D = b^2 - 4ac$	Nature of Roots
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D > 0 (not perfect square)	Real, irrational, distinct (conjugate surds)
D = 0	Real and equal (repeated root $x = -b/2a$)
D < 0	Imaginary (complex conjugate roots)
Complex roots occur in pairs	If a+ib is a root, so is a−ib (for real coefficients)

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Division trick	To divide complex numbers, multiply top & bottom by the conjugate of the denominator.
$z\cdot\bar{z} = \lvert z\rvert^2$	Always real and non-negative. Handy for rationalising.
Modulus	$\lvert z\rvert = \sqrt{(a^2 + b^2)}$; $\lvert z\rvert = \lvert\bar{z}\rvert = \lvert -z\rvert$.
Sum & product	$\alpha+\beta = -b/a$, $\alpha\beta = c/a$. Build equation: $x^2 - (\text{sum})x + (\text{product}) = 0$.
Discriminant	D>0 real distinct, D=0 real equal, D<0 complex conjugate pair.
Complex roots	For real coefficients, complex roots ALWAYS come in conjugate pairs.
Polar multiply	Multiply moduli, ADD arguments ; divide moduli, SUBTRACT arguments.

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Chapter 5 : Linear Inequalities (NCERT)

5.1 Basic Concepts

Concept	Detail
Inequality	A statement involving $<$, $>$, $\leq$, or $\geq$ between two expressions
Symbols	$<$ (less than), $>$ (greater than), $\leq$ (less than or equal), $\geq$ (greater than or equal)
Strict inequality	Uses $<$ or $>$ (endpoints NOT included)
Slack inequality	Uses $\leq$ or $\geq$ (endpoints included)
Linear inequality (1 variable)	$ax + b < 0$ (or $>$, $\leq$, $\geq$), $a \neq 0$
Linear inequality (2 variables)	$ax + by + c < 0$ (or $>$, $\leq$, $\geq$)
Solution	Any value of the variable that makes the inequality true

5.2 Rules for Solving Inequalities

Rule	Detail
Add / subtract	Add or subtract the same number on both sides — inequality unchanged
Multiply / divide by POSITIVE	Inequality sign stays the SAME
Multiply / divide by NEGATIVE	Inequality sign REVERSES ($<$ becomes $>$, $\leq$ becomes $\geq$)
Reciprocal (same sign terms)	Taking reciprocal reverses the inequality (for positive quantities)
Transposing	A term can shift sides with its sign changed

5.3 Solution on Number Line & Interval Notation

Inequality	Interval	Number Line
$x < a$	$(-\infty, a)$	Open circle at a, shade left
$x \leq a$	$(-\infty, a]$	Closed circle at a, shade left
$x > a$	(a, ∞)	Open circle at a, shade right
$x \geq a$	$[a, \infty)$	Closed circle at a, shade right
$a < x < b$	(a, b)	Open at both, shade between
$a \leq x \leq b$	$[a, b]$	Closed at both, shade between
$a \leq x < b$	$[a, b)$	Closed at a, open at b

5.4 Solving Steps (One Variable)

Step	Action
Step 1	Simplify both sides (remove brackets, fractions by LCM)
Step 2	Collect variable terms on one side, constants on the other (transpose)
Step 3	Divide/multiply by the coefficient of x

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Step	Action
Step 4 (key)	If dividing by a negative number, REVERSE the inequality sign
Step 5	Write solution in interval form and/or on the number line
System of inequalities	Solve each separately; final solution = INTERSECTION (common region)

5.5 Graphing Inequalities in Two Variables

Concept	Detail
Boundary line	Replace inequality with '=' to draw the line $ax + by + c = 0$
Strict (< or >)	Draw a DASHED line (boundary not included)
Slack (≤ or ≥)	Draw a SOLID line (boundary included)
Choosing the region	Pick a test point (usually origin); if it satisfies, shade that side
Origin test	If line does not pass through origin, test (0, 0) — easiest point
System / feasible region	Common shaded area satisfying ALL inequalities

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Golden rule	Multiplying or dividing by a NEGATIVE number FLIPS the inequality sign.
Brackets	Open ( ) excludes endpoint (use with < >) ; closed [ ] includes it (use with ≤ ≥).
Number line circles	Open (hollow) circle = strict ; closed (filled) circle = slack.
System = intersection	For 'and' systems, the answer is the OVERLAP of all solutions.
Dashed vs solid line	Strict → dashed boundary ; slack → solid boundary.
Origin test	Test (0,0) to decide which side to shade — unless the line passes through it.
Transposing	Move a term across with its sign changed — same as add/subtract both sides.
Word problems	Convert 'at least' → ≥, 'at most' → ≤, 'more than' → >, 'less than' → <.

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Chapter 6 : Permutations and Combinations (NCERT)

6.1 Fundamental Principle of Counting

Principle	Statement / Formula
Multiplication principle (AND)	If one event happens in m ways AND another in n ways, both happen in $m \times n$ ways
Addition principle (OR)	If one event happens in m ways OR another in n ways (mutually exclusive), total = $m + n$ ways
Key distinction	AND → multiply ; OR → add

6.2 Factorial Notation

Concept	Formula
Factorial n!	$n! = n \times (n-1) \times (n-2) \times \ldots \times 2 \times 1$
Zero & one	$0! = 1$; $1! = 1$
Recursive relation	$n! = n \times (n-1)!$
Example values	$2!=2$, $3!=6$, $4!=24$, $5!=120$, $6!=720$
Note	Factorial defined only for non-negative integers

6.3 Permutations (Arrangement — Order Matters)

Case	Formula
Permutations of n distinct, taken r	${}^nP_r = n! \div (n-r)!$
All n taken at a time	${}^nP_n = n!$
${}^nP_0$	$= 1$
Repetition allowed (r places)	n^r (each place filled in n ways)
Objects with repetition (p, q alike)	$n! \div (p!\, q!\, r! \ldots)$
Circular permutation (n objects)	$(n - 1)!$
Circular (clockwise = anticlockwise)	$(n - 1)! \div 2$ (e.g. necklace, garland)

6.4 Combinations (Selection — Order Doesn't Matter)

Case	Formula
Combinations of n distinct, taken r	${}^nC_r = n! \div [r!(n-r)!]$
${}^nC_0$ and ${}^nC_n$	$= 1$
${}^nC_1$	$= n$
Symmetry property	${}^nC_r = {}^nC_{(n-r)}$
Relation to permutation	${}^nP_r = {}^nC_r \times r!$
Pascal's rule	${}^nC_r + {}^nC_{(r-1)} = {}^{n+1}C_r$

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Case	Formula
If $^nC_x = {}^nC_y$	Then x = y OR x + y = n
Sum of all combinations	$^nC_0 + {}^nC_1 + \ldots + {}^nC_n = 2^n$

6.5 Permutation vs Combination

Aspect	Permutation	Combination
Meaning	Arrangement	Selection
Order	Matters	Does NOT matter
Formula	$^nP_r = n!/(n-r)!$	$^nC_r = n!/[r!(n-r)!]$
Relation	$^nP_r = {}^nC_r \times r!$	$^nC_r = {}^nP_r \div r!$
Keywords	arrange, order, rank, word, number	choose, select, team, group, committee

6.6 Common Problem Patterns

Problem Type	Approach
Words from letters	Use ^nP_r ; for repeated letters divide by factorials of repeats
Numbers with digits	Count place by place; watch for 'no repetition' and leading-zero cases
Always together	Tie the group as ONE unit, arrange, then arrange within the unit
Never together	(Total arrangements) − (arrangements with them together)
At least / at most	Add up the required cases (use combinations, sum them)
Forming committees	Use ^nC_r ; multiply choices for each sub-group (men AND women)
Handshakes / lines / diagonals	Handshakes = $^nC_2$; diagonals of n-gon = $^nC_2 - n$

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Order test	Order matters → Permutation (P) ; order doesn't → Combination (C).
AND vs OR	AND → multiply (fundamental principle) ; OR → add.
^nPr vs ^nCr	$^nPr = {}^nCr \times r!$ (permutation is r! times bigger — counts arrangements).
Symmetry	$^nCr = {}^nC(n-r)$. So $^{10}C7 = {}^{10}C3$ (pick the smaller for easy calc).
0! = 1	Remember 0! = 1 and $^nC0 = {}^nCn = 1$.
Together trick	'Always together' → glue as one unit, then multiply by internal arrangements.
Circular	n objects in a circle → (n−1)! ; necklace/garland → (n−1)!/2.
Handshakes	n people shaking hands = $^nC2 = n(n-1)/2$.

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Chapter 7 : Binomial Theorem (NCERT)

7.1 Binomial Theorem for Positive Integer n

Concept	Formula
Binomial expansion	$(a + b)^n = \Sigma\ ^nC_r\ a^{(n-r)}\ b^r$, $(r = 0$ to $n)$
Expanded form	$(a+b)^n = {}^nC_0a^n + {}^nC_1a^{(n-1)}b + {}^nC_2a^{(n-2)}b^2 + \ldots + {}^nC_nb^n$
Number of terms	$(n + 1)$ terms in the expansion
$(a - b)^n$	Same but with alternating signs: ${}^nC_r\ a^{(n-r)}\ (-b)^r$
$(1 + x)^n$	${}^nC_0 + {}^nC_1x + {}^nC_2x^2 + \ldots + {}^nC_nx^n$
$(1 - x)^n$	${}^nC_0 - {}^nC_1x + {}^nC_2x^2 - \ldots + (-1)^n\ {}^nC_nx^n$
Binomial coefficients	${}^nC_0$, ${}^nC_1$, …, ${}^nC_n$ (from Pascal's triangle)

7.2 General Term & Particular Terms

Term	Formula
General term (T_{r+1})	$T_{r+1} = {}^nC_r\ a^{(n-r)}\ b^r$ (the (r+1)th term)
For $(1 + x)^n$	$T_{r+1} = {}^nC_r\ x^r$
Term independent of x	Put the power of x = 0 in the general term, solve for r
Coefficient of x^k	Find r such that the power of x equals k, then evaluate ${}^nC_r$
r-th term from end	$= (n - r + 2)$th term from the beginning

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7.3 Middle Term(s)

Case	Middle Term
n is EVEN	One middle term: $T_{(n/2 + 1)}$
n is ODD	Two middle terms: $T_{(n+1)/2}$ and $T_{(n+3)/2}$
Example (n = 6, even)	Middle term = T_4 (the 4th term)
Example (n = 5, odd)	Middle terms = T_3 and T_4

7.4 Properties of Binomial Coefficients

Property	Formula
First & last	${}^nC_0 = {}^nC_n = 1$
Symmetry	${}^nC_r = {}^nC_{(n-r)}$
Sum of all coefficients	${}^nC_0 + {}^nC_1 + \ldots + {}^nC_n = 2^n$ (put a = b = 1)
Sum of even-position	${}^nC_0 + {}^nC_2 + {}^nC_4 + \ldots = 2^{(n-1)}$
Sum of odd-position	${}^nC_1 + {}^nC_3 + {}^nC_5 + \ldots = 2^{(n-1)}$
Alternating sum	${}^nC_0 - {}^nC_1 + {}^nC_2 - \ldots = 0$ (put a = 1, b = −1)

Property	Formula
Pascal's rule	${}^{n}C_r + {}^{n}C_{(r-1)} = {}^{n+1}C_r$
Ratio of consecutive	${}^{n}C_r \div {}^{n}C_{(r-1)} = (n - r + 1) \div r$

7.5 Pascal's Triangle (Coefficients)

Power n	Coefficients
$(a+b)^0$	1
$(a+b)^1$	1 1
$(a+b)^2$	1 2 1
$(a+b)^3$	1 3 3 1
$(a+b)^4$	1 4 6 4 1
$(a+b)^5$	1 5 10 10 5 1
$(a+b)^6$	1 6 15 20 15 6 1
Rule	Each entry = sum of the two entries above it

7.6 Common Applications

Application	Method
Greatest coefficient	n even → ${}^{n}C_{(n/2)}$; n odd → ${}^{n}C_{(n-1)/2} = {}^{n}C_{(n+1)/2}$
Approximation (small x)	$(1 + x)^n \approx 1 + nx$ (when x is very small, higher powers ignored)
Divisibility / remainder	Write the number as (something ± 1)^n and expand
Finding a specific term	Use the general term T_{r+1} and match the required power
Numerically greatest term	Find r using $(n-r+1)\|x\| \div (r) \geq 1$, solve for the boundary r

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General term	$T_{r+1} = {}^{n}Cr\ a^{(n-r)}\ b^{r}$. This single formula solves most problems.
Number of terms	Expansion of $(a+b)^n$ has (n+1) terms.
Middle term	n even → ONE middle term $T_{(n/2+1)}$; n odd → TWO middle terms.
Sum of coefficients	Put a=b=1 → 2^n. Put a=1,b=−1 → 0 (for n≥1).
Even = Odd sums	Even-indexed and odd-indexed coefficient sums are each $2^{(n-1)}$.
Independent of x	Set the net power of x to 0 in T_{r+1} and solve for r.
Approximation	For tiny x: $(1+x)^n \approx 1 + nx$ (drop higher powers).
Pascal	Each row's ends are 1 ; inner entries add the two above.

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Chapter 8 : Sequences and Series (NCERT)

8.1 Basic Definitions

Term	Definition
Sequence	An ordered list of numbers following a rule ; $a_1, a_2, a_3, \ldots$
Series	Sum of the terms of a sequence ; $a_1 + a_2 + a_3 + \ldots$
Finite sequence	Has a definite (countable) number of terms
Infinite sequence	Continues without end
General (nth) term	a_n — formula giving any term directly

8.2 Arithmetic Progression (AP)

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Concept	Formula
AP form	a, a+d, a+2d, … (a = first term, d = common difference)
Common difference	$d = a_n - a_{(n-1)}$
nth term	$a_n = a + (n - 1)d$
nth term from end	$= l - (n - 1)d$ (l = last term)
Sum of n terms	$S_n = (n/2)[2a + (n - 1)d]$
Sum (first & last known)	$S_n = (n/2)(a + l)$
nth term from sum	$a_n = S_n - S_{(n-1)}$
Arithmetic mean (AM)	AM of a and b = $(a + b)/2$
n AMs between a, b	Common difference $d = (b - a)/(n + 1)$

8.3 Geometric Progression (GP)

Concept	Formula
GP form	$a, ar, ar^2, \ldots$ (a = first term, r = common ratio)
Common ratio	$r = a_n \div a_{(n-1)}$
nth term	$a_n = a\, r^{(n-1)}$
Sum of n terms (r ≠ 1)	$S_n = a(r^n - 1)/(r - 1) = a(1 - r^n)/(1 - r)$
Sum when r = 1	$S_n = na$
Sum to infinity (|r| < 1)	$S_\infty = a \div (1 - r)$
Geometric mean (GM)	GM of a and b = $\sqrt{(ab)}$
n GMs between a, b	Common ratio $r = (b/a)^{(1/(n+1))}$

8.4 Relation Between AM, GM (and HM)

Concept	Formula
Arithmetic mean	$A = (a + b)/2$
Geometric mean	$G = \sqrt{(ab)}$
Harmonic mean	$H = 2ab/(a + b)$
AM–GM inequality	$A \geq G \geq H$ (equal only when $a = b$)
Key relation	$G^2 = A \times H$ (G is the GM of A and H)

8.5 Sums of Special Series

Series	Sum Formula
First n natural numbers	$\Sigma n = n(n + 1)/2$
First n odd numbers	$1 + 3 + 5 + \ldots = n^2$
First n even numbers	$2 + 4 + 6 + \ldots = n(n + 1)$
Sum of squares	$\Sigma n^2 = n(n + 1)(2n + 1)/6$
Sum of cubes	$\Sigma n^3 = [n(n + 1)/2]^2 = (\Sigma n)^2$
Note	Sum of cubes = square of the sum of naturals

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8.6 Useful AP/GP Selection Tricks

Number of terms	Convenient Way to Take Them
3 terms in AP	$a - d, a, a + d$
4 terms in AP	$a - 3d, a - d, a + d, a + 3d$ (common difference 2d)
5 terms in AP	$a - 2d, a - d, a, a + d, a + 2d$
3 terms in GP	$a/r, a, ar$
4 terms in GP	$a/r^3, a/r, ar, ar^3$ (common ratio r^2)
Why use these	Makes the sum/product symmetric and easy to solve

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AP nth term	$a_n = a + (n-1)d$. Sum $S_n = (n/2)[2a+(n-1)d] = (n/2)(a+l)$.
GP nth term	$a_n = ar^{(n-1)}$; Sum = $a(r^n-1)/(r-1)$; Infinite sum = $a/(1-r)$ when $\lvert r\rvert < 1$.
AM-GM-HM	$A \geq G \geq H$ always ; and $G^2 = A \cdot H$.
Special sums	$\Sigma n = n(n+1)/2$; $\Sigma n^2 = n(n+1)(2n+1)/6$; $\Sigma n^3 = (\Sigma n)^2$.
Odd/even sums	First n odds = n^2 ; first n evens = $n(n+1)$.
3-term tricks	AP: $a-d, a, a+d$; GP: $a/r, a, ar$ — symmetry simplifies everything.
a_n from S_n	$a_n = S_n - S_{(n-1)}$ works for ANY series.
Mean insertion	AP: $d = (b-a)/(n+1)$; GP: $r = (b/a)^{(1/(n+1))}$.

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Chapter 9 : Straight Lines (NCERT)

9.1 Basic Coordinate Formulas

Concept	Formula
Distance between two points	$d = \sqrt{[(x_2-x_1)^2 + (y_2-y_1)^2]}$
Section formula (internal)	$P = [(mx_2+nx_1)/(m+n) , (my_2+ny_1)/(m+n)]$
Section formula (external)	$P = [(mx_2-nx_1)/(m-n) , (my_2-ny_1)/(m-n)]$
Midpoint	$M = [(x_1+x_2)/2 , (y_1+y_2)/2]$
Centroid of triangle	$G = [(x_1+x_2+x_3)/3 , (y_1+y_2+y_3)/3]$
Area of triangle	$\frac{1}{2} \lvert x_1(y_2-y_3) + x_2(y_3-y_1) + x_3(y_1-y_2)\rvert$
Collinearity condition	Area of triangle = 0

9.2 Slope of a Line

Concept	Formula
Slope (two points)	$m = (y_2 - y_1) \div (x_2 - x_1)$
Slope from angle	$m = \tan\theta$ (θ = angle with positive x-axis)
Horizontal line	Slope = 0 (parallel to x-axis)
Vertical line	Slope = undefined (parallel to y-axis)
Parallel lines	$m_1 = m_2$ (equal slopes)
Perpendicular lines	$m_1 \times m_2 = -1$
Angle between two lines	$\tan\theta = \lvert(m_1 - m_2) \div (1 + m_1m_2)\rvert$

9.3 Forms of the Equation of a Line

Form	Equation
Slope-intercept	$y = mx + c$ (m = slope, c = y-intercept)
Point-slope	$y - y_1 = m(x - x_1)$
Two-point	$y - y_1 = [(y_2-y_1)/(x_2-x_1)](x - x_1)$
Intercept form	$x/a + y/b = 1$ (a = x-intercept, b = y-intercept)
Normal (perpendicular) form	$x \cos\omega + y \sin\omega = p$ (p = $\perp$ distance from origin)
General form	$Ax + By + C = 0$
Horizontal line	$y = b$ (or $y = k$)
Vertical line	$x = a$ (or $x = k$)

9.4 General Form Ax + By + C = 0 — Key Results

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Quantity	Formula
Slope	$m = -A \div B$
x-intercept	$= -C \div A$
y-intercept	$= -C \div B$
Parallel line	$Ax + By + k = 0$ (only constant changes)
Perpendicular line	$Bx - Ay + k = 0$ (swap & change one sign)
Convert to normal form	Divide by $\pm\sqrt{(A^2 + B^2)}$

9.5 Distance Formulas

Concept	Formula
Point to line	$d = \|Ax_1 + By_1 + C\| \div \sqrt{(A^2 + B^2)}$
Distance from origin	$d = \|C\| \div \sqrt{(A^2 + B^2)}$
Between two parallel lines	$d = \|C_1 - C_2\| \div \sqrt{(A^2 + B^2)}$
Foot of perpendicular	Use point-to-line and slope conditions

9.6 Special Lines & Conditions

Concept	Detail
Line through intersection	$(A_1x + B_1y + C_1) + \lambda(A_2x + B_2y + C_2) = 0$
Concurrent lines	Three lines meet at a point ; determinant of coefficients = 0
Equation of x-axis	$y = 0$; y-axis: $x = 0$
Line parallel to axes	Through (a, b): $x = a$ (vertical), $y = b$ (horizontal)
Angle of inclination	θ where $0° \le \theta < 180°$; slope $m = \tan\theta$
Shifting of origin	New coords: $X = x - h$, $Y = y - k$ (origin moved to (h, k))

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Slope	$m = (y_2-y_1)/(x_2-x_1) = \tan\theta$. Vertical line → undefined slope.
Parallel vs perpendicular	Parallel: $m_1 = m_2$; Perpendicular: $m_1 \cdot m_2 = -1$.
General form slope	For $Ax+By+C=0$, slope $= -A/B$ (just negate A over B).
Point-to-line	$d = \|Ax_1+By_1+C\|/\sqrt{(A^2+B^2)}$. Same denominator for parallel-line distance.
Which form?	Slope+intercept → $y=mx+c$; two points → two-point form ; intercepts → $x/a+y/b=1$.
Area = 0	Three points are collinear when the triangle area is zero.
Angle between lines	$\tan\theta = \|(m_1-m_2)/(1+m_1m_2)\|$.
Family of lines	$L_1 + \lambda L_2 = 0$ passes through the intersection of L_1 and L_2 for all λ.

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Chapter 10 : Conic Sections (NCERT)

10.1 Circle

Concept	Formula
Standard equation (centre origin)	$x^2 + y^2 = r^2$
Centre (h, k), radius r	$(x - h)^2 + (y - k)^2 = r^2$
General equation	$x^2 + y^2 + 2gx + 2fy + c = 0$
Centre from general form	$(-g, -f)$
Radius from general form	$r = \sqrt{(g^2 + f^2 - c)}$
Condition for a circle	Coefficient of x^2 = coefficient of y^2, no xy term
Diameter form	$(x - x_1)(x - x_2) + (y - y_1)(y - y_2) = 0$

10.2 Parabola

Type (vertex at origin)	Equation & Key Features
Right: $y^2 = 4ax$	Focus (a, 0) ; directrix $x = -a$; axis: x-axis
Left: $y^2 = -4ax$	Focus (−a, 0) ; directrix $x = a$
Up: $x^2 = 4ay$	Focus (0, a) ; directrix $y = -a$; axis: y-axis
Down: $x^2 = -4ay$	Focus (0, −a) ; directrix $y = a$
Latus rectum length	= 4a (for all standard parabolas)
Eccentricity	$e = 1$
Definition	Set of points equidistant from focus and directrix

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10.3 Ellipse

Concept	Horizontal: $x^2/a^2 + y^2/b^2 = 1$ (a > b)
Vertices	$(\pm a, 0)$
Foci	$(\pm c, 0)$, where $c^2 = a^2 - b^2$
Major axis length	2a (along x-axis)
Minor axis length	2b (along y-axis)
Eccentricity	$e = c/a = \sqrt{(1 - b^2/a^2)}$; $0 < e < 1$
Latus rectum length	$= 2b^2/a$
Directrices	$x = \pm a/e$
Sum of focal distances	= 2a (constant, the defining property)
Vertical ellipse (b > a)	$x^2/a^2 + y^2/b^2 = 1$ with foci on y-axis, $c^2 = b^2 - a^2$

10.4 Hyperbola

Concept	Horizontal: $x^2/a^2 - y^2/b^2 = 1$
Vertices	$(\pm a, 0)$
Foci	$(\pm c, 0)$, where $c^2 = a^2 + b^2$
Transverse axis length	2a
Conjugate axis length	2b
Eccentricity	$e = c/a = \sqrt{(1 + b^2/a^2)}$; $e > 1$
Latus rectum length	$= 2b^2/a$
Directrices	$x = \pm a/e$
Asymptotes	$y = \pm(b/a)x$
Difference of focal distances	= 2a (constant, defining property)
Conjugate hyperbola	$y^2/b^2 - x^2/a^2 = 1$ (foci on y-axis)

10.5 Eccentricity & Comparison

Conic	Eccentricity (e)	Defining Property
Circle	$e = 0$	All points equidistant from centre
Ellipse	$0 < e < 1$	Sum of distances from 2 foci constant
Parabola	$e = 1$	Equidistant from focus & directrix
Hyperbola	$e > 1$	Difference of distances from 2 foci constant
Relation (ellipse)	$c^2 = a^2 - b^2$	$c = ae$
Relation (hyperbola)	$c^2 = a^2 + b^2$	$c = ae$

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Circle radius	From $x^2+y^2+2gx+2fy+c=0$: centre $(-g,-f)$, radius $\sqrt{(g^2+f^2-c)}$.
Parabola LR	Latus rectum = 4a ; focus at distance a from vertex along the axis.
y^2 vs x^2	$y^2 = 4ax$ opens sideways (along x) ; $x^2 = 4ay$ opens up/down (along y).
Ellipse c	$c^2 = a^2 - b^2$ (subtract). Foci INSIDE. Sum of focal distances = 2a.
Hyperbola c	$c^2 = a^2 + b^2$ (add). Difference of focal distances = 2a.
Eccentricity ladder	Circle 0 < Ellipse <1 = Parabola 1 < Hyperbola. e tells the shape.
Latus rectum (ellipse/hyperbola)	Both = $2b^2/a$ — same formula.
Asymptotes	Only the hyperbola has them: $y = \pm(b/a)x$.

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Chapter 11 : Introduction to Three Dimensional Geometry (NCERT)

11.1 Coordinate Axes & Planes

Concept	Detail
Three axes	x-axis, y-axis, z-axis — mutually perpendicular, meeting at origin O
Coordinates of a point	P(x, y, z)
Coordinate planes	XY-plane (z=0), YZ-plane (x=0), ZX-plane (y=0)
Octants	The three planes divide space into 8 octants
Point on x-axis	(x, 0, 0) ; on y-axis (0, y, 0) ; on z-axis (0, 0, z)
Point in XY-plane	(x, y, 0) ; YZ-plane (0, y, z) ; ZX-plane (x, 0, z)

11.2 Signs of Coordinates in Octants

Octant	x	y	z
I	+	+	+
II	−	+	+
III	−	−	+
IV	+	−	+
V	+	+	−
VI	−	+	−
VII	−	−	−
VIII	+	−	−

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11.3 Distance Formula

Concept	Formula
Distance between two points	$PQ = \sqrt{[(x_2-x_1)^2 + (y_2-y_1)^2 + (z_2-z_1)^2]}$
Distance from origin	$OP = \sqrt{(x^2 + y^2 + z^2)}$
Collinearity of 3 points	Sum of two distances = third distance (A, B, C collinear)

11.4 Section Formula

Concept	Formula
Internal division (ratio m:n)	$P = [(mx_2+nx_1)/(m+n), (my_2+ny_1)/(m+n), (mz_2+nz_1)/(m+n)]$
External division (ratio m:n)	$P = [(mx_2-nx_1)/(m-n), (my_2-ny_1)/(m-n), (mz_2-nz_1)/(m-n)]$
Midpoint	$M = [(x_1+x_2)/2, (y_1+y_2)/2, (z_1+z_2)/2]$
Centroid of triangle	$G = [(x_1+x_2+x_3)/3, (y_1+y_2+y_3)/3, (z_1+z_2+z_3)/3]$
Ratio in which point divides	Find k from one coordinate: $x = (kx_2+x_1)/(k+1)$

11.5 Key Facts & Special Cases

Concept	Detail
Distance is always positive	Square root gives the non-negative value
Equidistant point	Set PA = PB and solve (locus is a plane)
Point dividing a line	Use section formula; negative ratio means external
Coordinate plane distances	Distance from XY-plane = $\lvert z\rvert$; YZ-plane = $\lvert x\rvert$; ZX-plane = $\lvert y\rvert$
Distance from axes	From x-axis = $\sqrt{(y^2+z^2)}$; from y-axis = $\sqrt{(x^2+z^2)}$; from z-axis = $\sqrt{(x^2+y^2)}$

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3D distance	Just add the z-term: $\sqrt{[(\Delta x)^2 + (\Delta y)^2 + (\Delta z)^2]}$. Same as 2D plus one dimension.
Octant I	All three coordinates positive (+, +, +) — like the first quadrant extended.
Plane membership	$z = 0 \rightarrow$ on XY-plane ; $x = 0 \rightarrow$ YZ-plane ; $y = 0 \rightarrow$ ZX-plane.
Axis membership	Two coordinates zero → on an axis (e.g. (x,0,0) is on x-axis).
Midpoint	Average each coordinate — works the same in 3D as in 2D.
Distance from a plane	Drop the matching coordinate: from XY-plane it's just $\lvert z\rvert$.
Distance from an axis	Combine the OTHER two coordinates: from z-axis it's $\sqrt{(x^2+y^2)}$.
External division	Use minus signs in the section formula ($m-n$ in denominator).

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Chapter 12 : Limits and Derivatives (NCERT)

12.1 Limits — Basic Concept & Algebra

Concept	Formula
Limit notation	lim $(x \to a)$ $f(x) = L$
Left-hand limit (LHL)	lim $(x \to a^-)$ $f(x)$
Right-hand limit (RHL)	lim $(x \to a^+)$ $f(x)$
Limit exists if	LHL = RHL (both equal & finite)
Sum / difference	lim $(f \pm g)$ = lim f ± lim g
Product	lim $(f \cdot g)$ = (lim f)(lim g)
Quotient	lim (f/g) = (lim f) ÷ (lim g), if lim g ≠ 0
Constant multiple	lim (k f) = k lim f

12.2 Standard Limits

Limit	Value
lim $(x \to a)$ $(x^{n - a}n)/(x - a)$	$n\,a^{(n-1)}$
lim $(x \to 0)$ (sin x)/x	1
lim $(x \to 0)$ (tan x)/x	1
lim $(x \to 0)$ (1 − cos x)/x	0
lim $(x \to 0)$ (1 − cos x)/x^2	1/2
lim $(x \to 0)$ $(e^{x - 1)/x}$	1
lim $(x \to 0)$ $(a^{x - 1)/x}$	$\log_e a$
lim $(x \to 0)$ log(1+x)/x	1
lim $(x \to 0)$ $(1 + x)^{(1/x)}$	e

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12.3 Methods of Evaluating Limits

Method	When to Use
Direct substitution	Put x = a if result is defined (not 0/0 or ∞/∞)
Factorisation	For 0/0 form: factor & cancel the common term
Rationalisation	When square roots cause 0/0 (multiply by conjugate)
Standard limit formulas	Convert to a known limit (sin x/x etc.)
Substitution method	Replace to convert into a standard form

12.4 Derivative — Definition (First Principle)

Concept	Formula
Derivative (first principle)	f'(x) = lim (h→0) [f(x+h) − f(x)] ÷ h
Derivative at a point	f'(a) = lim (h→0) [f(a+h) − f(a)] ÷ h
Meaning	Slope of tangent / instantaneous rate of change
Notation	f'(x) = dy/dx = d/dx [f(x)]

12.5 Standard Derivatives

Function	Derivative
x^n	n $x^{(n-1)}$
constant (c)	0
sin x	cos x
cos x	−sin x
tan x	$\sec^2$ x
cot x	−cosec^2 x
sec x	sec x tan x
cosec x	−cosec x cot x
e^x	e^x
a^x	$a^{x \log_e} a$
$\log_e$ x	1/x
√**x**	1 ÷ (2√x)

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12.6 Rules of Differentiation

Rule	Formula
Sum / difference	(u ± v)' = u' ± v'
Constant multiple	(k u)' = k u'
Product rule	(uv)' = u'v + uv'
Quotient rule	(u/v)' = (u'v − uv') ÷ v^2
Power rule	d/dx ($x^{n) = n\,x}$(n−1)
Chain rule (idea)	d/dx f(g(x)) = f'(g(x)) · g'(x)

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Limit exists	Only when LHL = RHL. Always check both sides for piecewise functions.
sin x / x	lim(x→0) sinx/x = 1 — the most-used limit. Also tanx/x = 1.
0/0 form	Factor, rationalise, or use a standard limit — never just substitute.
First principle	f'(x) = lim(h→0)[f(x+h)−f(x)]/h. The definition of the derivative.
Trig derivatives	sin→cos, cos→−sin, tan→$\sec^2$. The 'co' functions get the minus sign.

Product rule	$(uv)' = u'v + uv'$ — 'first times derivative of second, plus...'
Quotient rule	$(u/v)' = (u'v - uv')/v^2$. Order matters — numerator derivative first.
e^x is special	$d/dx(e^x) = e^x$ — the only function that is its own derivative.

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Chapter 13 : Statistics (NCERT)

13.1 Measures of Central Tendency

Measure	Formula
Mean (ungrouped)	$\bar{x} = (\Sigma x_i) \div n$
Mean (grouped, direct)	$\bar{x} = (\Sigma f_i x_i) \div (\Sigma f_i)$
Mean (assumed mean method)	$\bar{x} = A + (\Sigma f_i d_i) \div (\Sigma f_i)$; $d_i = x_i - A$
Mean (step-deviation)	$\bar{x} = A + h \times (\Sigma f_i u_i) \div (\Sigma f_i)$; $u_i = (x_i - A)/h$
Median (ungrouped, odd n)	Middle value of sorted data
Median (ungrouped, even n)	Average of the two middle values
Mode	Value with highest frequency
Empirical relation	Mode = 3 Median − 2 Mean

13.2 Measures of Dispersion — Range & Mean Deviation

Measure	Formula
Range	Maximum value − Minimum value
Coefficient of range	(Max − Min) ÷ (Max + Min)
Mean deviation about mean	$MD(\bar{x}) = (\Sigma f_i\lvert x_i - \bar{x}\rvert) \div (\Sigma f_i)$
Mean deviation about median	$MD(M) = (\Sigma f_i\lvert x_i - M\rvert) \div (\Sigma f_i)$
Ungrouped MD about mean	$(\Sigma\lvert x_i - \bar{x}\rvert) \div n$
Coefficient of MD	MD ÷ (mean or median)
Least MD	MD about MEDIAN is the least

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13.3 Variance & Standard Deviation

Measure	Formula
Variance (ungrouped)	$\sigma^2 = (\Sigma(x_i - \bar{x})^2) \div n$
Variance (grouped)	$\sigma^2 = (\Sigma f_i(x_i - \bar{x})^2) \div N$; $N = \Sigma f_i$
Variance (shortcut)	$\sigma^2 = (\Sigma f_i x_i^2)/N - (\Sigma f_i x_i/N)^2$
Standard deviation	$\sigma = \sqrt{(\text{variance})}$
SD (step-deviation)	$\sigma = (h/N)\ \sqrt{[N\ \Sigma f_i u_i^2 - (\Sigma f_i u_i)^2]}$
Coefficient of variation (CV)	$CV = (\sigma \div \bar{x}) \times 100\%$
More consistent data	Lower CV → more consistent/uniform

13.4 Key Properties & Comparison

Concept	Detail
Effect of adding constant	Mean changes by the constant ; variance & SD unchanged
Effect of multiplying constant	Mean × k ; SD × $\lvert k \rvert$; variance × k^2
Variance is always	Non-negative (≥ 0)
SD units	Same as the data ; variance has squared units
Comparing two groups	Use CV — smaller CV is more consistent
Most affected by extremes	Range & mean (median & mode are robust)

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Three averages	Mean = average ; Median = middle ; Mode = most frequent.
Empirical relation	Mode = 3 Median − 2 Mean (connects all three).
Mean deviation	Least about the MEDIAN. MD = Σ|deviations|/n.
Variance shortcut	$\sigma^2 = (\Sigma fx^2)/N - (\text{mean})^2$. Faster than the deviation method.
SD vs variance	SD = √variance ; SD has the same units as the data.
Adding a constant	Shifts the mean but leaves SD/variance UNCHANGED.
Multiplying by k	Mean ×k, SD ×|k|, variance ×k^2.
Coefficient of variation	$CV = (\sigma/\bar{x}) \times 100\%$. Lower CV = more consistent data.

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CLASS 11 MATHEMATICS — FORMULA SHEET

Chapter 14 : Probability (NCERT)

14.1 Basic Terms

Term	Definition
Random experiment	An experiment with more than one possible outcome that can't be predicted with certainty
Sample space (S)	Set of all possible outcomes
Sample point	Each element (outcome) of the sample space
Event	A subset of the sample space
Equally likely outcomes	Outcomes with the same chance of occurring
Trial	A single performance of the experiment

14.2 Types of Events

Type	Definition
Sure (certain) event	The whole sample space S ; probability 1
Impossible event	Empty set φ ; probability 0
Simple (elementary) event	Event with a single outcome
Compound event	Event with more than one outcome
Complementary event (A')	'Not A' = $S - A$
Mutually exclusive	$A \cap B = \varphi$ (cannot occur together)
Exhaustive events	Their union covers all of S
Independent events	Occurrence of one does not affect the other

14.3 Probability — Definitions & Range

Concept	Formula
Probability of event A	$P(A)$ = (favourable outcomes) ÷ (total outcomes)
Range of probability	$0 \le P(A) \le 1$
Sure event	$P(S) = 1$
Impossible event	$P(\varphi) = 0$
Sum over sample space	$\Sigma P(\text{outcomes}) = 1$
Complement rule	$P(A') = 1 - P(A)$
Odds in favour	$P(A) : P(A')$

14.4 Addition Theorem (Union of Events)

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Concept	Formula
Union of two events	$P(A \cup B) = P(A) + P(B) - P(A \cap B)$
Mutually exclusive	$P(A \cup B) = P(A) + P(B)$ (since $A \cap B = \varphi$)
Three events	$P(A\cup B\cup C) = \Sigma P(A) - \Sigma P(A\cap B) + P(A\cap B\cap C)$
Either A or B (not both)	$P(A) + P(B) - 2P(A \cap B)$
Neither A nor B	$P(A' \cap B') = 1 - P(A \cup B)$
Only A (not B)	$P(A) - P(A \cap B)$

14.5 Common Sample Spaces

Experiment	Total Outcomes
One coin tossed	2 (H, T)
Two coins / one coin twice	4 (HH, HT, TH, TT)
n coins tossed	2^n
One die rolled	6
Two dice rolled	36
n dice rolled	6^n
Drawing 1 card from a deck	52 (4 suits × 13)
Face cards in a deck	12 (J, Q, K of each suit)

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Basic probability	$P(A)$ = favourable / total. Always between 0 and 1.
Complement	$P(\text{not } A) = 1 - P(A)$. Often easier to find the complement first.
Addition theorem	$P(A\cup B) = P(A) + P(B) - P(A\cap B)$. Subtract the overlap once.
Mutually exclusive	$A\cap B = \varphi$, so just add: $P(A\cup B) = P(A) + P(B)$.
Independent events	$P(A\cap B) = P(A)\cdot P(B)$ when one doesn't affect the other.
Coins & dice	n coins → 2^n outcomes ; n dice → 6^n outcomes.
Card deck	52 cards: 26 red, 26 black, 12 face cards, 4 aces.
'At least one'	$P(\text{at least one}) = 1 - P(\text{none})$. The complement trick saves time.

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