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CUET · MATHEMATICS · CLASS XI · CODE 319

Sets

CUET unit: Sets

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📌 Snapshot

- Establishes the foundational language of modern mathematics — every later topic (relations, functions, probability, geometry, calculus) is built on set notation and membership logic.
- Defines a set as a well-defined collection of objects and fixes the symbols N, Z, Q, R, Z^+, Q^+, R^+, ∈, ∉, ϕ once and for all.
- Introduces two equivalent ways to describe a set — roster (tabular) form and set-builder form — and the classifications: empty, finite, infinite, equal, singleton, subset, proper subset, universal.
- Develops the algebra of sets through three binary operations (union, intersection, difference) plus the unary complement, supported by Venn diagrams.
- The algebraic laws — commutative, associative, distributive, identity, idempotent, complement laws and De Morgan's laws — let you simplify purely symbolic set expressions.
- Provides the formula $n(A \cup B) = n(A) + n(B) - n(A \cap B)$ used in word problems on survey-type counting questions every year.

📖 Detailed Notes

2.1 Core concepts

Origin and motivation. The theory of sets was developed by Georg Cantor (1845–1918) while working on trigonometric series; the concept of a set is now a fundamental part of present-day mathematics and underlies relations, functions, geometry, sequences and probability (NCERT §1.1, p. 1). Cantor's revolutionary idea was to treat infinite collections as completed mathematical objects — a step that drew controversy in his lifetime but is now standard.

Definition of a set. A set is a well-defined collection of objects — meaning, given any object, we can decide unambiguously whether or not it belongs (NCERT §1.2, p. 2). Thus "the rivers of India" is a set, but "the five most renowned mathematicians of the world" is not, because the criterion is subjective. NCERT cites further well-defined collections: odd natural numbers less than 10, the rivers of India, vowels in the English alphabet, all even integers; and ill-defined collections like the most talented writers of India or honest persons of a country (p. 2).

Notation conventions. Objects, elements and members are synonyms; sets are denoted by capital letters (A, B, C, X, Y, Z) and elements by small letters (a, b, c, x, y, z). The symbol $\in$ is read "belongs to" and $\notin$ "does not belong to" (NCERT §1.2, p. 2). For example if V is the set of vowels then $a \in V$ but $b \notin V$.

Standard number sets. N (natural numbers), Z (integers), Q (rationals), R (reals), Z^+, Q^+, R^+ (their positive parts) carry fixed meanings throughout (NCERT §1.2, p. 2). The letter T is later used for the set of irrationals (p. 10). These names recur in every later chapter, so memorising them is non-negotiable.

Roster (tabular) form. All elements are listed inside braces { }, separated by commas; order is immaterial and elements are not repeated. For example, letters of "SCHOOL" → {S, C, H, O, L}. Dots are used to indicate an indefinite continuation: {1, 3, 5, ⋯} for the set of all positive odd numbers (NCERT §1.2, p. 2–3).

Set-builder form. All elements share a common property not possessed by any element outside the set, written V = {x : x is a vowel in English alphabet}. The colon ":" reads "such that" and the braces read "the set of all" (NCERT §1.2, p. 3). NCERT often asks the student to translate between the two forms — e.g. $\{1, 4, 9, 16, 25, \cdots\} = \{x : x = n^2, n \in N\}$.

Empty / null / void set. A set containing no element, denoted ϕ or { }. Examples: $\{x : 1 < x < 2, x \in N\}$, $\{x : x^2 - 2 = 0$ and x is rational$\}$, even primes greater than 2 — all are empty (NCERT §1.3, p. 5–6).

Finite vs infinite sets. A set is finite if it is empty or has a definite number of elements; otherwise it is infinite. n(S) denotes the number of distinct elements. All infinite sets cannot be written in roster form — e.g. the set of real numbers does not follow a pattern (NCERT §1.4, p. 6–7).

Equal sets. A = B iff every element of A is in B and every element of B is in A. Repetition is irrelevant: {1, 2, 3} = {2, 2, 1, 3, 3} (NCERT §1.5, p. 7–8).

Subsets and proper subsets. $A \subset B$ if every element of A is also an element of B, i.e. $a \in A \Rightarrow a \in B$. Every set is a subset of itself; ϕ is a subset of every set. $A \subset B$ and $B \subset A \Leftrightarrow A = B$ (NCERT §1.6, p. 9). If $A \subset B$ and $A \neq B$, then A is a proper subset of B, and B is the superset of A (p. 10). A singleton set contains exactly one element, e.g. {a}.

Subsets of R. $N \subset Z \subset Q$, $Q \subset R$, $T \subset R$ (T = irrationals), and $N \not\subset T$ (NCERT §1.6.1, p. 10–11). Intervals: for a < b: open $(a, b) = \{y : a < y < b\}$; closed $[a, b] = \{x : a \leqslant x \leqslant b\}$; half-open [a, b), (a, b]. $(-\infty, \infty)$ is R. The length of any of these intervals is $b - a$ (NCERT §1.6.2, p. 11–12).

Universal set, Venn diagrams. The universal set U is the basic set relevant to a context; all subsets in that context are taken from U (NCERT §1.7, p. 12). Venn diagrams, named after John Venn (1834–1883), depict U as a rectangle and its subsets as closed curves (usually circles).

Set operations. Union: $A \cup B = \{x : x \in A \text{ or } x \in B\}$; common elements counted once. If $B \subset A$ then $A \cup B = A$. Intersection: $A \cap B = \{x : x \in A \text{ and } x \in B\}$; if $A \cap B = \phi$, the sets are disjoint. Difference: $A - B = \{x : x \in A \text{ and } x \notin B\}$; in general $A - B \neq B - A$. The three sets $A - B$, $A \cap B$, $B - A$ are mutually disjoint (NCERT §1.9, p. 14–17).

Complement. $A' = \{x : x \in U \text{ and } x \notin A\} = U - A$; obviously $A' \subset U$ and $(A')' = A$. **De Morgan's laws:** $(A \cup B)' = A' \cap B'$ and $(A \cap B)' = A' \cup B'$ — the complement of a union is the intersection of complements, and vice versa (NCERT §1.10, p. 18–19).

Algebraic laws. Union and intersection are commutative and associative; ∩ distributes over ∪ and vice versa; identity laws $A \cup \phi = A$, $U \cap A = A$; idempotent $A \cup A = A$, $A \cap A = A$; complement laws $A \cup A' = U$, $A \cap A' = \phi$; double complementation $(A')' = A$; and $\phi' = U$, $U' = \phi$ (NCERT §1.9.1–1.10, p. 14–20).

2.2 Definitions to memorise

Term	Definition	Page
Set	A well-defined collection of objects	2
Element / member	An object belonging to a set; ∈ means "belongs to"	2
Roster form	All elements listed inside braces, separated by commas	2
Set-builder form	{x : x has property P}; elements share one common property	3
Empty / null / void set	Set with no element, denoted ϕ or { }	5
Finite set	Empty set or set with a definite number of elements	6
Infinite set	A set that is not finite	6
Cardinal number n(S)	Number of distinct elements of set S	6
Equal sets	A = B iff every element of A is in B and vice versa	7
Equivalent sets	Sets with the same cardinal number (need not be equal)	7
Subset ($A \subset B$)	$a \in A \Rightarrow a \in B$	9
Proper subset	$A \subset B$ and $A \neq B$	10
Superset	If $A \subset B$ then B is superset of A	10
Singleton set	A set with exactly one element	10
Power set P(A)	Set of all subsets of A;	P(A)
Open interval (a, b)	$\{y : a < y < b\}$; endpoints excluded	11
Closed interval [a, b]	$\{x : a \leqslant x \leqslant b\}$; endpoints included	11
Length of an interval	b – a, for any of (a,b), [a,b], [a,b), (a,b]	12
Universal set U	Basic set whose subsets are under discussion	12
Union $A \cup B$	$\{x : x \in A \text{ or } x \in B\}$	14
Intersection $A \cap B$	$\{x : x \in A \text{ and } x \in B\}$	15

Term	Definition	Page
Disjoint sets	$A \cap B = \phi$	15
Difference A – B	$\{x : x \in A \text{ and } x \notin B\}$	16
Complement A′	$\{x : x \in U \text{ and } x \notin A\} = U - A$	18
De Morgan's laws	$(A \cup B)' = A' \cap B'$; $(A \cap B)' = A' \cup B'$	19

2.3 Diagrams / processes to remember

NCERT supplies a small but crucial gallery of Venn diagrams. Memorise the visual shape of each so you can re-create the answer instantly:

- **Fig 1.1, p. 11** — Real-number line showing open, closed and half-open intervals as subsets of R. The open endpoint is an empty circle; the closed endpoint is a filled circle.
- **Fig 1.2 and Fig 1.3, p. 13** — Venn diagram of universal set $U = \{1,\cdots,10\}$ with subset $A = \{2,4,6,8,10\}$, and a second showing $B \subset A$ with $B = \{4, 6\}$. The proper-subset diagram is one circle drawn entirely inside another.
- **Fig 1.4, p. 14** — Two overlapping circles with the entire shaded region representing $A \cup B$. The union covers both lobes and the central lens.
- **Fig 1.5, p. 15** — Two overlapping circles with only the central lens shaded — $A \cap B$. This is the most common Venn shape on CUET answer keys.
- **Fig 1.6, p. 15** — Two non-overlapping circles representing disjoint sets A and B (no lens, no overlap).
- **Figs 1.7 (i)–(v), p. 16** — Five-step Venn-diagram proof of the distributive law $A \cap (B \cup C) = (A \cap B) \cup (A \cap C)$. Students should trace through each shading step at least once.
- **Fig 1.8, p. 17** — Shaded crescent representing $A - B$; only the part of A that lies outside B.
- **Fig 1.9, p. 17** — Three mutually disjoint regions $A - B$, $A \cap B$, $B - A$ — together they partition $A \cup B$.
- **Fig 1.10, p. 19** — Universal-set rectangle with circle A; shaded region outside the circle (inside the rectangle) is A′.

Process for finding $n(A \cup B \cup C)$. Step 1 — write the addition formula $n(A\cup B\cup C) = n(A) + n(B) + n(C) - n(A\cap B) - n(B\cap C) - n(C\cap A) + n(A\cap B\cap C)$. Step 2 — substitute the given counts. Step 3 — solve for whichever quantity is unknown. This is the standard tool for the "students who read three newspapers" type problem.

Process for converting roster ↔ set-builder. Look for a pattern: arithmetic progression → $\{x : x = a + (n-1)d\}$; squares → $\{x : x = n^2\}$; multiples → $\{x : x = kn\}$. Conversely, plug consecutive n = 1, 2, 3 ⋯ into the rule to write the roster.

2.4 Common confusions / NTA trap points

- **"Well-defined" vs "any collection".** A collection like "ten most talented writers" is not a set because membership is subjective (NCERT §1.2, p. 2; Exercise 1.1 Q1).
- **Element vs subset.** For A = {1, 2, {3, 4}, 5}, the object {3, 4} is an element of A (so {3, 4} ∈ A) and {{3, 4}} is a subset of A — NCERT explicitly warns that an element should not be confused with the singleton containing it (Example 11 and Exercise 1.3 Q3, p. 10, 12).
- **$\phi \subset A$ always; $\phi \in A$ only if ϕ is listed.** The empty set is a subset of every set, but it is an element of a set only when written inside its braces (NCERT §1.6, p. 9; Exercise 1.3 Q3).
- **A – B ≠ B – A.** Difference is not commutative — students assume it behaves like ∪ or ∩ (NCERT §1.9.3, Example 18, p. 16).
- **De Morgan flips the connective.** (A ∪ B)′ becomes A′ ∩ B′, not A′ ∪ B′. NTA often offers both as distractors (NCERT §1.10, Example 22, p. 19).
- **"Equal" requires same elements, not same count.** {1, 2, 3} and {a, b, c} have the same n(S) but are not equal — only sets with identical elements are equal. They are however equivalent (NCERT §1.5, Definition 3, p. 7).
- **Roster repetition.** Letters of "FOLLOW" → {F, O, L, W}; repeated letters are listed once. Distractors keep duplicates to trap (NCERT §1.2 Note, p. 3; Exercise 1.2 Q5).
- **Power-set count.** $|P(A)| = 2^n$, not n^2 — a frequent CUET swap. For A with 4 elements, P(A) has $2^4 = 16$ subsets, not 16 elements of A.
- **Intervals with mixed endpoints.** [a, b) includes a but excludes b. Re-read every option before committing.
- **Inclusion–exclusion sign error.** In n(A ∪ B) = n(A) + n(B) − n(A ∩ B), the intersection is subtracted, not added — a classic algebra slip.
- **ϕ vs $\{\phi\}$.** ϕ has zero elements; $\{\phi\}$ has one element (namely ϕ). So $|\{\phi\}| = 1$.

2.5 Key formulas & theorems

Formula / Theorem	Statement	NCERT page
Roster ↔ Set-builder	{1, 4, 9, ⋯} =	3
Cardinality of empty set	$n(\phi) = 0$	6
Equality of sets	A = B ⇔ A ⊂ B and B ⊂ A	7
Subset reflexivity	A ⊂ A for every set A	9
Empty set as subset	$\phi \subset A$ for every set A	9
Power-set cardinality	If |A| = n then $|P(A)| = 2^n$	12
Length of an interval	(a, b), [a, b], [a, b), (a, b] all have length b – a	12

Formula / Theorem	Statement	NCERT page
Commutative law	A ∪ B = B ∪ A ; A ∩ B = B ∩ A	14, 15
Associative law	(A ∪ B) ∪ C = A ∪ (B ∪ C) ; similarly ∩	14, 15
Identity law	A ∪ ϕ = A ; U ∩ A = A	14, 15
Idempotent law	A ∪ A = A ; A ∩ A = A	14, 15
Distributive law (∩ over ∪)	A ∩ (B ∪ C) = (A ∩ B) ∪ (A ∩ C)	16
Distributive law (∪ over ∩)	A ∪ (B ∩ C) = (A ∪ B) ∩ (A ∪ C)	16
Complement law	A ∪ A′ = U ; A ∩ A′ = ϕ	19
Double complement	(A′)′ = A	19
Empty-universe pair	ϕ′ = U ; U′ = ϕ	19
De Morgan I	(A ∪ B)′ = A′ ∩ B′	19
De Morgan II	(A ∩ B)′ = A′ ∪ B′	19
A – B in terms of ∩	A – B = A ∩ B′	18
Disjoint union	If A ∩ B = ϕ then n(A ∪ B) = n(A) + n(B)	(Misc)
Two-set inclusion-exclusion	n(A ∪ B) = n(A) + n(B) − n(A ∩ B)	(Misc)
Three-set inclusion-exclusion	n(A∪B∪C) = n(A)+n(B)+n(C) − n(A∩B) − n(B∩C) − n(C∩A) + n(A∩B∩C)	(Misc)
Subset count of finite set	Number of subsets of n-element set = 2^n	12
Proper-subset count	Number of proper subsets of n-element set = 2^n – 1	12

2.6 Solved examples

Example 1 — Power set count. Find the number of subsets and proper subsets of A = {1, 2, 3, 4, 5}.

Step 1 — |A| = 5. Step 2 — Number of subsets = 2^5 = 32. Step 3 — Number of proper subsets = 2^5 – 1 = 31 (excludes A itself). **Answer:** 32 subsets, 31 proper subsets.

Example 2 — Inclusion-exclusion (two sets). In a class of 100 students, 60 read English newspapers, 35 read Hindi newspapers, and 25 read both. How many read at least one?

Step 1 — n(E) = 60, n(H) = 35, n(E ∩ H) = 25. Step 2 — n(E ∪ H) = n(E) + n(H) − n(E ∩ H) = 60 + 35 − 25 = 70. **Answer:** 70 students read at least one newspaper.

Example 3 — Three-set survey. In a survey of 200 students: 80 like tea, 100 like coffee, 70 like milk; 35 tea+coffee, 30 coffee+milk, 20 tea+milk, 10 like all three. How many like none?

Step 1 — $n(T \cup C \cup M) = 80 + 100 + 70 - 35 - 30 - 20 + 10 = 175$. Step 2 — Students liking none $= 200 - 175 = 25$. **Answer:** 25 students like none.

Example 4 — Set algebra simplification. Simplify $(A \cup B) \cap (A \cup B')$.

Step 1 — Distribute ∩ over ∪: $A \cup (B \cap B')$. Step 2 — Complement law: $B \cap B' = \phi$. Step 3 — Identity: $A \cup \phi = A$. **Answer:** A.

Example 5 — De Morgan in computation. If $U = \{1,2,\cdots,10\}$, $A = \{2,4,6,8,10\}$, $B = \{1,3,5,7,9\}$, verify $(A \cup B)' = A' \cap B'$.

Step 1 — $A \cup B = \{1,2,\cdots,10\} = U$, so $(A \cup B)' = \phi$. Step 2 — $A' = \{1,3,5,7,9\} = B$; $B' = \{2,4,6,8,10\} = A$; $A' \cap B' = B \cap A = \phi$. **Answer:** Both sides equal ϕ — verified.

🎯 Practice MCQs

📊 PYQ Alignment

Sets is a high-yield chapter in CUET (UG) Mathematics — typically 6–8 MCQs per year drawing on set notation, roster ↔ set-builder conversion, intervals, identification of null/finite/infinite sets, power-set counting, inclusion-exclusion word problems, and direct application of De Morgan's laws or complement identities. Statement-correctness, match-the-following on interval notation, and assertion–reason questions on subset/element distinctions and De Morgan's laws are recurrent NTA favourites.

For the full PYQ archive across all Mathematics chapters, see **/pyq/mathematics**.