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CHAPTER NOTES

Relations and Functions Class 11 Notes | CBSE Maths Chapter 2

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Relations and Functions Class 11 Notes | CBSE Maths Chapter 2

Relations and Functions is Chapter 2 of CBSE Class 11 Maths — the chapter that finally tells you, precisely, what a “function” actually *is*. Everything you will do later in Trigonometry, Limits, Derivatives, and all of Class 12 Calculus rests on the ideas built here: ordered pairs, the Cartesian product, relations, and functions as a special kind of relation.

By the end of these notes you will be able to write the Cartesian product of two sets, identify whether a relation is a function, state the domain, codomain and range of any relation, recognise all the standard real functions (identity, constant, polynomial, modulus, signum, greatest integer), and add, subtract, multiply and divide real functions confidently. This chapter is short but scoring — roughly 4–6 marks in boards and a guaranteed concept-builder for JEE.

Table of Contents

- Key Concepts — Cartesian product, relations, functions, types of functions, domain & range, algebra of functions
 - Weightage in Board & Entrance Exams
 - Important Definitions
 - Solved Examples
 - Important Questions for Board Exams
 - Quick Revision Points
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Key Concepts

1. Ordered Pairs and Cartesian Product of Sets

An **ordered pair** is a pair of elements written in a fixed order, like (a, b) . Order matters — $(2, 3)$ is *not* the same as $(3, 2)$. Two ordered pairs are equal only when their corresponding entries are equal: $(a, b) = (c, d)$ means $a = c$ and $b = d$.

The **Cartesian product** of two sets A and B , written $A \times B$, is the set of all ordered pairs (a, b) where a belongs to A and b belongs to B .

$$A \times B = \{(a, b) : a \in A \text{ and } b \in B\}$$

- If $A = \{1, 2\}$ and $B = \{3, 4\}$, then $A \times B = \{(1,3), (1,4), (2,3), (2,4)\}$.
 - In general, $A \times B \neq B \times A$ (unless $A = B$ or one of them is empty).
 - If $n(A) = p$ and $n(B) = q$, then $n(A \times B) = pq$.
 - $A \times A \times A$ is the set of ordered triples — for example, $\mathbb{R} \times \mathbb{R} \times \mathbb{R}$ represents 3-dimensional space.
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2. Relations

A **relation** R from a set A to a set B is a subset of the Cartesian product $A \times B$. It simply picks out the ordered pairs that are “related” by some rule.

$R \subseteq A \times B$; we write $a R b$ (or $(a, b) \in R$) to mean a is related to b .

For example, if $A = \{1, 2, 3, 4\}$ and the rule is “ $y = x + 1$ ”, then $R = \{(1,2), (2,3), (3,4)\}$ — a subset of $A \times A$.

- **Domain of R :** the set of all first elements of the ordered pairs in R .
- **Range of R :** the set of all second elements of the ordered pairs in R .
- **Codomain of R :** the whole set B (the range is always a subset of the codomain).

Number of relations: If $n(A) = p$ and $n(B) = q$, then $A \times B$ has pq elements, so the number of possible relations from A to B is $2^{(pq)}$.

3. Functions — a Special Kind of Relation

A **function** f from a set A to a set B is a relation in which every element of A has **exactly one** image in B . No element of A is left out, and none is paired with two different outputs.

We write $f : A \rightarrow B$, and if $(a, b) \in f$ we write $b = f(a)$ — b is the image of a , and a is a pre-image of b .

- Every function is a relation, but not every relation is a function.
- **Domain:** set A (all valid inputs). **Codomain:** set B . **Range:** the set of actual outputs $f(a)$ — a subset of B .
- **Vertical line test:** a graph represents a function if no vertical line cuts it more than once.

[DIAGRAM: An arrow diagram — each element of set A has exactly one arrow leaving it to set B . A relation where one element of A points to two elements of B is NOT a function.]

4. Real-Valued and Real Functions

A function whose **range** is a subset of the real numbers R is called a **real-valued function**. If, in addition, its **domain** is also a subset of R , it is called a **real function**. Almost every function you meet in this chapter is a real function.

5. Types of Functions (Standard Real Functions)

(i) Identity Function

$f(x) = x$ for every real x . Each input maps to itself. Domain = R , Range = R . Its graph is the straight line $y = x$ through the origin at 45° .

(ii) Constant Function

$f(x) = c$, where c is a fixed real number, for every x . Domain = $\mathbb{R}$, Range = $\{c\}$. Its graph is a horizontal line parallel to the x -axis.

(iii) Polynomial Function

$f(x) = a_0 + a_1x + a_2x^2 + \dots + a_nx^n$, where the powers of x are non-negative integers and the coefficients are real. Domain = $\mathbb{R}$. Examples: $f(x) = 3$, $f(x) = 2x + 1$, $f(x) = x^2 - 5x + 6$.

(iv) Rational Function

A function of the form $f(x) = p(x)/q(x)$, where $p(x)$ and $q(x)$ are polynomials and $q(x) \neq 0$. Domain = $\mathbb{R}$ except the values of x that make the denominator zero. For $f(x) = 1/x$, domain = $\mathbb{R} - \{0\}$, range = $\mathbb{R} - \{0\}$.

(v) Modulus (Absolute Value) Function

$f(x) = |x|$, which equals x when $x \geq 0$ and $-x$ when $x < 0$. It always gives a non-negative output. Domain = $\mathbb{R}$, Range = $[0, \infty)$. Its graph is a V-shape with the vertex at the origin.

(vi) Signum Function

The signum function tells you the sign of x :

$$f(x) = 1 \text{ for } x > 0, \quad 0 \text{ for } x = 0, \quad -1 \text{ for } x < 0.$$

Equivalently $f(x) = |x|/x$ for $x \neq 0$, and 0 at $x = 0$. Domain = $\mathbb{R}$, Range = $\{-1, 0, 1\}$.

(vii) Greatest Integer Function (Step Function)

$f(x) = [x]$ gives the greatest integer less than or equal to x . For example $[2.7] = 2$, $[3] = 3$, $[-1.2] = -2$. Domain = $\mathbb{R}$, Range = $\mathbb{Z}$ (the integers). Its graph looks like a staircase, hence "step function".

6. Domain and Range of Real Functions

To find the **domain**, ask: for which real x is $f(x)$ defined? Two situations to watch:

- **Denominator $\neq 0$:** for a rational function, exclude values that make the denominator zero.
- **Even root ≥ 0 :** for $\sqrt{\text{expression}}$, the expression under the root must be ≥ 0 .

To find the **range**, ask: what set of output values can $f(x)$ actually take? Express x in terms of y where possible, or analyse the function's behaviour.

- For $f(x) = \sqrt{x}$: domain = $[0, \infty)$, range = $[0, \infty)$.
 - For $f(x) = 1/(x - 2)$: domain = $\mathbb{R} - \{2\}$, range = $\mathbb{R} - \{0\}$.
 - For $f(x) = \sqrt{9 - x^2}$: domain = $[-3, 3]$, range = $[0, 3]$.
-

7. Algebra of Real Functions

If f and g are two real functions with domains D_f and D_g , we can combine them. The combined functions are defined on the common domain $D_f \cap D_g$ (with one extra rule for division).

Operation	Definition	Domain
Sum	$(f + g)(x) = f(x) + g(x)$	$D_f \cap D_g$
Difference	$(f - g)(x) = f(x) - g(x)$	$D_f \cap D_g$
Product	$(fg)(x) = f(x) \cdot g(x)$	$D_f \cap D_g$
Scalar multiple	$(cf)(x) = c \cdot f(x)$, c a constant	D_f
Quotient	$(f/g)(x) = f(x)/g(x)$	$D_f \cap D_g$, with $g(x) \neq 0$

Key idea: the only special case is division — you must additionally throw out every x where $g(x) = 0$.

Weightage in Board & Entrance Exams

Exam	Typical Weightage	Most-Tested Areas
CBSE Board (Class 11)	4–6 marks	Cartesian product, domain & range, identifying functions, algebra of functions
JEE Main	1–2 questions (with Class 12 functions)	Domain & range, greatest integer, modulus, signum
School Unit Tests	5–8 marks	$n(A \times B)$, relations as subsets, graphs of standard functions

[TABLE: Question-type split — VSA (1 mark): definitions, $n(A \times B)$, value of $[x]$ or $|x|$; SA (2–3 marks): finding domain/range, checking if a relation is a function; LA (4–5 marks): algebra of functions, drawing graphs of standard functions.]

Important Definitions

Term	Definition
Ordered pair	A pair (a, b) where order matters; $(a,b) = (c,d)$ iff $a = c$ and $b = d$
Cartesian product	$A \times B = \{(a, b) : a \in A, b \in B\}$; $n(A \times B) = n(A) \cdot n(B)$
Relation	Any subset R of $A \times B$
Domain of a relation	Set of all first elements of the ordered pairs in R
Range of a relation	Set of all second elements of the ordered pairs in R
Codomain	The set B from which images are drawn; $\text{range} \subseteq \text{codomain}$
Function	A relation in which every element of the domain has exactly one image
Identity function	$f(x) = x$ for all $x \in R$
Modulus function	$f(x) = x $; equals x if $x \geq 0$, $-x$ if $x < 0$
Signum function	$f(x) = 1, 0, -1$ for $x > 0, x = 0, x < 0$ respectively
Greatest integer function	$f(x) = [x] = \text{greatest integer} \leq x$

Solved Examples

Example 1

If $A = \{1, 2\}$ and $B = \{3, 4, 5\}$, find $A \times B$ and $n(A \times B)$.

Answer: $A \times B = \{(1,3), (1,4), (1,5), (2,3), (2,4), (2,5)\}$. $n(A \times B) = n(A) \cdot n(B) = 2 \times 3 = 6$.

Example 2

If $(x + 1, y - 2) = (3, 1)$, find x and y.

Answer: Equating components: $x + 1 = 3 \Rightarrow x = 2$; $y - 2 = 1 \Rightarrow y = 3$.

Example 3

Let $A = \{1, 2, 3, 4, 5\}$ and $R = \{(x, y) : y = x + 2\}$. Write R, its domain and range.

Answer: $R = \{(1,3), (2,4), (3,5)\}$. Domain = $\{1, 2, 3\}$, Range = $\{3, 4, 5\}$.

Example 4

Which of these relations on $\{1, 2, 3\}$ is a function? (a) $\{(1,1), (2,2), (3,3)\}$ (b) $\{(1,2), (1,3), (2,3)\}$

Answer: (a) is a function — every input has exactly one output. (b) is **not** a function because the input 1 has two images (2 and 3).

Example 5

Find the domain and range of $f(x) = 1/(x - 3)$.

Answer: The denominator is zero at $x = 3$, so Domain = $\mathbf{R - \{3\}}$. The output is never 0, so Range = $\mathbf{R - \{0\}}$.

Example 6

If $f(x) = x^2$ and $g(x) = 2x + 1$, find $(f + g)(x)$ and $(f/g)(x)$ and state the domain of f/g .

Answer: $(f + g)(x) = x^2 + 2x + 1$. $(f/g)(x) = x^2/(2x + 1)$, defined for all real x except where $2x + 1 = 0$, so domain = $\mathbf{R - \{-1/2\}}$.

Example 7

Evaluate $[-2.5] + |-4| + \text{signum}(-6)$.

Answer: $[-2.5] = -3$, $|-4| = 4$, $\text{signum}(-6) = -1$. Sum = $-3 + 4 - 1 = \mathbf{0}$.

Important Questions for Board Exams

1-Mark Questions (VSA)

1. Define the Cartesian product of two sets A and B.
2. If $n(A) = 3$ and $n(B) = 4$, how many relations are possible from A to B?
3. Write the value of $[-3.7]$ (greatest integer function).
4. State the range of the signum function.
5. Is every relation a function? Give a reason.

2–3-Mark Questions (SA)

1. If $A = \{-1, 0, 1\}$ and $B = \{2, 3\}$, find $A \times B$ and $B \times A$. Are they equal?
2. Find the domain and range of $f(x) = \sqrt{x - 2}$.
3. Let $R = \{(x, y) : x, y \in \mathbf{N} \text{ and } y = 2x, x \leq 4\}$. Write R in roster form and give its domain and range.
4. Sketch the graph of the modulus function $f(x) = |x|$ and state its domain and range.

4–5-Mark Questions (LA)

1. Define a function. Explain, with an arrow diagram and the vertical line test, why every function is a relation but every relation need not be a function.
 2. For $f(x) = x^2 + 1$ and $g(x) = x - 1$, find $f + g$, $f - g$, fg and f/g , stating the domain of each.
 3. Draw the graphs of the identity function, the constant function, and the greatest integer function, and write the domain and range of each.
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Quick Revision Points

- Ordered pair (a, b) : order matters; equal iff components are equal
 - $A \times B = \{(a, b) : a \in A, b \in B\}$; $n(A \times B) = n(A) \cdot n(B)$; $A \times B \neq B \times A$ in general
 - Relation = any subset of $A \times B$; number of relations = 2^{pq}
 - Function = relation where each input has exactly one output
 - Domain = inputs, Codomain = target set B , Range = actual outputs ($\subseteq$ codomain)
 - Identity $f(x) = x$; Constant $f(x) = c$; Range $\{c\}$
 - Modulus $|x|$: range $[0, \infty)$; Signum: range $\{-1, 0, 1\}$
 - Greatest integer $[x]$: greatest integer $\leq x$; range = $\mathbb{Z}$
 - Rational $p(x)/q(x)$: exclude $q(x) = 0$ from the domain
 - Even roots: expression under $\sqrt{\quad}$ must be ≥ 0
 - Algebra of functions: $(f \pm g)$, (fg) , (cf) , (f/g) with $g(x) \neq 0$; combine on $D_f \cap D_g$
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Next Chapter: Chapter 3 — Trigonometric Functions



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