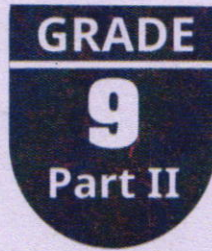


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GANITA MANJARI

Textbook of Mathematics



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NCERT

राष्ट्रीय शैक्षिक अनुसंधान और प्रशिक्षण परिषद्
NATIONAL COUNCIL OF EDUCATIONAL RESEARCH AND TRAINING

0905 - GANITA MANJARI

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FOREWORD

The National Education Policy (NEP) 2020 envisions an education system that is firmly rooted in India's cultural and intellectual wisdom, values, and ethical traditions. The rich intellectual heritage simultaneously enables learners to engage meaningfully with the complexities and possibilities of a rapidly changing world. The National Curriculum Framework for School Education (NCF-SE) 2023 provides concrete expression to this vision by laying out a coherent curricular pathway across various stages of schooling that nurtures critical thinking, creativity, and sensitivity, along with the values and dispositions that are needed for responsible citizenship in an interconnected global society.

Learners have progressed through the Foundational, Preparatory, and Middle Stages, where their inherent potential has been nurtured holistically. Now, they enter the Secondary Stage with enhanced capacity for reflection, reasoning, enquiry, and self-expression. Spanning across Grades 9 to 12. It marks a crucial period in the intellectual and personal growth of the students. It prepares them to engage with abstract ideas, complex social realities, ethical dilemmas, and the expanding universe of knowledge, while deepening their understanding of the self and the world around them.

The NCF-SE 2023 recommends that the curriculum for Grades 9–10 equips students with the skills that are needed to grow as they advance in their lives. Students can use these skills for reasoning, argumentation, and effective communication. It endeavours to enhance their analytical and descriptive capabilities to prepare them for the challenges and opportunities that await them. A diverse curriculum, covering ten subjects: three languages—including at least two languages native to India—Science, Mathematics, Social Sciences, Art Education, Physical Education and Well-being, Individuals in Society/Environmental Education, Skill Education, and AI and Computational Thinking, promotes their holistic development.

As per NCF-SE 2023, the Secondary Stage focuses on further developing students' ability to justify claims and arguments through logical reasoning. At this stage, students are expected to be comfortable working with abstractions and core techniques of Mathematics and Computational Thinking, such as mathematical modelling and algorithm development for problem-solving. They also need to strengthen key mathematical skills, including problem-solving, visualisation, optimisation, representation, and communication, thereby building essential capacities in Mathematics and Computational

Thinking. Engaging with puzzles, word problems, and optimisation tasks helps nurture values and dispositions, such as perseverance, curiosity, confidence, rigour, and honesty.

The Grade 9 Mathematics textbook, *Ganita Manjari* (Part II), is in continuation of *Ganita Manjari* (Part I), and carries forward the vision of NEP 2020 and NCF-SE 2023 by promoting mathematical thinking, problem-solving skills, and intuition among students. Mathematical thinking involves systematic and logical approaches to interpreting the world. This textbook aims to develop students' ability in formulating well-defined problems that can be addressed through mathematical reasoning — an essential aspect of learning Mathematics. It also fosters mathematical intuition, enabling students to develop a sense of what is likely to be true in Mathematics, which is a key goal of school education.

This textbook marks an important transition from the Middle Stage to the Secondary Stage of Mathematics. While building on students' prior experiences, it introduces greater conceptual depth, formal reasoning, and the foundations of proof. Through real-life examples and collaborative learning experiences, it enhances creativity, logical reasoning, and decision-making skills. This textbook also highlights the rich history of Mathematics in India, spanning thousands of years. By learning about mathematical developments in India and across the world, students can develop a deeper sense of cultural rootedness. The content attempts to integrate mathematics with other subject areas, such as Science, Social Science and with cross-cutting themes like environmental education, value education and inclusive education. Additionally, the inclusion of QR codes integrates technology, providing access to a variety of learning resources.

The National Council of Educational Research and Training acknowledges the contributions of the textbook development team, subject experts, pedagogues, practising teachers, reviewers, and all others who have supported the development of this textbook. We hope *Ganita Manjari* inspires learners to think critically, communicate with confidence, and engage thoughtfully in society and the global community. We also warmly welcome suggestions and feedback from all its users for further improvement in the subsequent editions.

DINESH PRASAD SAKLANI
Director

National Council of Educational
Research and Training

New Delhi
August, 2026

ABOUT THE BOOK

Mathematics at the Secondary Stage plays a crucial role in deepening students' understanding of structure, pattern, and reasoning, while also strengthening their ability to communicate ideas clearly and precisely. At this stage, mathematics moves beyond familiarity with ideas to a more systematic engagement with concepts, representations, and arguments. It supports the development of logical thinking, problem-solving, and the capacity to reason with increasing abstraction, skills that are essential not only for further study in mathematics and science, but also for informed participation in society.

The Grade 9 Mathematics textbook, *Ganita Manjari*, marks an important transition from the Middle Stage to Secondary mathematics. While remaining connected to students' prior experiences, the textbook introduces greater conceptual depth, formal reasoning, and the beginnings of proof. The chapters are carefully structured to support this transition through sequential concept building, allowing students to progress from intuitive understanding to more formal ideas in a coherent and meaningful manner. The Low Threshold–High Ceiling (LTHC) approach has been adopted to ensure accessibility for all learners while providing opportunities for deeper exploration.

Each chapter begins with an engaging introduction, often rooted in exploration or real-life contexts, to motivate the ideas that follow. Concepts are developed using multiple representations—pictorial, numerical, algebraic, and graphical, so that students learn to move flexibly between different ways of thinking about mathematical ideas. Visualisation plays a central role in making abstract concepts accessible, particularly in areas, such as number systems, algebra, sequences, and mensuration.

The textbook places strong emphasis on meaningful problem solving through a rich variety of worked examples, practice problems, application-based exercises and problems requiring higher order thinking skills. Selected questions are designed to challenge students to explain their reasoning, construct arguments, and gradually engage with ideas of justification and proof. Games, puzzles, and exploratory tasks are incorporated to foster computational thinking, logical reasoning, and curiosity. Some problems in each chapter are marked with an asterisk (*). These problems require higher-order thinking and deeper reasoning, and are meant for those students who wish

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to explore the topic in greater depth. Further, some chapters include sections marked with (*), designed to engage motivated students in extended inquiry and project-based work. These, in the form of enrichment materials including technology-enabled explorations, open-ended tasks and additional readings, are provided to encourage independent inquiry and deeper engagement with ideas.

Questions and sections marked with (*) are intended for enrichment, and are not to be assessed or included in examinations.

Historical references and contextual connections are included wherever appropriate to help students appreciate mathematics as a human endeavour that has evolved over ages and across cultures.

The textbook consists of six chapters that build conceptual understanding, while gradually introducing students to more formal mathematical ideas, including definitions, argumentation, proof, data interpretation, algorithmic thinking, algebraic representation, and spatial reasoning. Concepts are developed through exploration, familiar contexts, multiple representations, and opportunities to explain and justify mathematical ideas.

In alignment with the NCF-SE 2023 the textbook emphasises competency-based learning, conceptual coherence, and mathematical reasoning over rote procedures, promotes connections across mathematical domains and with real-life contexts, and supports diverse learning pathways through activities, explorations, and opportunities for discussion. Collectively, the chapters aim to build coherence across topics, promote representational fluency, and support a smooth transition from intuitive reasoning to formal mathematical thinking at the secondary level. Data in various forms may appear across chapters. However, it is included solely for illustrative purposes.

Chapter 9, 'Propositions and their Converses', discusses the important distinction between proving a statement and its converse in the fields of geometry and number theory. Chapter 10, 'How Quantities Combine: Understanding Data', develops the idea of weighted averages, showing how they arise in various daily life situations such as combining data, mixtures, and rating/mark schemes, and how they differ from simple averages. It also introduces stacked and 100% stacked bar charts as tools to compare totals versus proportions, and explores what kinds of inferences each visualisation allows or hides. Chapter 11, 'The World of Algorithms', introduces algorithms as systematic procedures, and uses addition and the greatest common divisor (gcd) to show how we design, justify, and refine them. It builds from simple dot-counting and divisor-listing to increasingly efficient gcd methods, ending in

Euclid's remainder-based algorithm. Chapter 12, 'Quadrilaterals', develops a precise, exploratory study of quadrilaterals (especially parallelograms), using midpoint and median properties in triangles and quadrilaterals to build powerful geometric tools and real-world applications. It culminates in showing that the plane can be tiled using any 4-gon, connecting school geometry with ideas like Varignon's theorem, centroids, and aperiodic tilings. Chapter 13, 'Two Variables, One Line', builds the concept of linear equations in two variables, their solutions as ordered pairs and graphs, and the slope-intercept form, then considers pairs of linear equations and methods to solve them (substitution, elimination, and graphical). It also classifies pairs of linear equations by number of solutions (unique, none, infinitely many), ties these to algebraic coefficient conditions and geometric interpretations (intersecting, parallel, coincident lines), and embeds all ideas in rich, real-life and historical problem contexts. Chapter 14, 'Math of Space: Surface Area and Volume', develops formulas for surface area and volume of key three-dimensional (3D) solids—cuboids, cylinders, cones, pyramids, spheres and hemispheres—and connects them to everyday objects and applications. It also uses 'guesstimate' contexts and modelling activities to build intuitive understanding of these measurements, their patterns, and their role in real-world problem solving.

Together, the chapters aim to help students move beyond routine application of formulas and procedures. They encourage learners to represent ideas in different ways, identify patterns, make conjectures, justify conclusions, evaluate arguments, and use mathematics to understand and solve problems in meaningful contexts.

This textbook is designed to support diverse learners in the classroom, and to encourage discussion, collaboration, and reflection. By emphasising connectedness across chapters and revisiting ideas in a spiralling manner, it aims to help students see mathematics as a coherent and unified discipline. Above all, the book seeks to nurture confidence, curiosity, and a growing appreciation of the power and beauty of mathematics, laying a strong foundation for further learning at the senior secondary level.

About the Title: *Ganita Manjari* brings together two ideas—*Ganita*, the timeless word for mathematics, and *Manjari*, which in various Indian languages, means a bouquet of flowers. Like a carefully gathered bunch of blossoms, this Grade 9 textbook presents Mathematics as a collection of ideas—each topic a distinct petal, rich with its own colour, shape, and fragrance. The title reflects the vibrant colours and creative



aspects of mathematics, and its deep connections with beauty and nature. Through patterns, reasoning, and discovery, students will see how mathematics blooms all around us—in art, in the natural world, and in everyday life. We hope that *Ganita Manjari* will entice students to explore the beautiful bouquet of ideas that make up Grades 9 and 10 mathematics.

ASHUTOSH WAZALAWAR
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NOTE TO THE TEACHER

The Grade 9 Mathematics textbook, *Ganita Manjari*, is intended to support you in the important task of guiding students as they transition from middle school to secondary school mathematics, a stage where ideas become more abstract, and reasoning, justification and connections across concepts assume greater significance. At this level, mathematics learning must move beyond following procedures to making sense of underlying structures, relationships, and representations.

Classrooms that encourage students to actively engage with ideas by exploring patterns, making conjectures, testing examples, justifying claims, and discussing alternative approaches, all of which are essential for developing mathematical thinking. Students should be given regular opportunities to reason, argue, and communicate their ideas, both orally and in writing. Such practices reflect how mathematics itself develops, and help students see mathematics as a meaningful and connected discipline rather than a collection of rules.

Creating this environment does not require elaborate arrangements. Posing a carefully chosen question, encouraging multiple paths of inquiry and solution strategies, while allowing adequate time for discussion and reflection can significantly enrich classroom learning. Equally important is nurturing a classroom culture where errors are treated as opportunities for learning and refinement of ideas. 'Think and Reflect' is a special feature which has been added to this book. As you navigate the content of the chapters, these questions will enable you to engage students in the class, to delve deeper into a new concept and to facilitate whole-class discussion.

As mathematical justification and proof begin to assume a more prominent role at this stage, students should be gently guided towards explaining why results hold, without undue pressure for formalism. Encouraging experimentation, use of examples and counterexamples, and intuitive reasoning can support this progression towards more formal arguments.

The textbook includes a variety of problems designed to promote exploration, reasoning, and consolidation of concepts. Attempting to 'cover' all problems mechanically should be avoided if it compromises opportunities for deep engagement. Problems appear in the chapters in the form of practice exercises as well as end-of-chapter exercises. The practice exercises appear after each section and will enable the student

to understand and apply the concept as well as acquire the procedural fluency needed. The end-of-chapter exercises include problems drawn from concepts across the chapter, and are intended to help students consolidate the concepts and skills developed. In addition, some questions are marked with an asterisk (*). **These problems require higher-order thinking and deeper reasoning, and they are not meant for assessment and will not be asked in examinations.**

An emphasis is also placed on developing students as independent learners. Reading mathematical text, interpreting definitions, and making sense of worked examples are important skills at this level. Encouraging students to read the textbook independently and discuss their interpretations can help them gain confidence in engaging with mathematical language. The enrichment material provided at the end of some chapters is intended for students who are motivated to explore the ideas of the chapter beyond what is required at this stage. This material is meant to encourage deeper engagement and curiosity, and will not form part of the formal evaluation.

Finally, this textbook includes ideas and approaches that may be new or challenging, even for teachers. It is perfectly acceptable if some aspects require reflection or further exploration. Opening such ideas for classroom discussion and approaching them as a co-learner can model intellectual curiosity and perseverance, setting a powerful example for students.

Summary of Key Points

Time for Exploration

- Regularly pose questions, problems, and challenges that encourage reasoning and discussion.
- Allow sufficient time for individual and group exploration.
- Foster an environment where mistakes are valued as a part of learning.

About the Problems in the Book

- Exploratory problems aim to deepen conceptual understanding as well as support procedural fluency.
- Depth of engagement should take precedence over quantity of problems covered.

Reading and Communication

- Encourage students to read, interpret, and explain mathematical ideas in their own words.
- Promote discussion as a means to clarify thinking and build mathematical language.

Right of Not Knowing

- Some ideas may not be immediately clear; this is a natural part of learning mathematics.
- Treat uncertainty as a starting point for inquiry and discussion, both for students and teachers.

A NOTE TO STUDENTS

As you embark on your journey of learning mathematics in Grade 9, it will be good to keep in mind that mathematics is not something to be watched from a distance, but something you learn by actively engaging with it. True understanding comes from thinking, questioning, exploring ideas, and sometimes struggling with them, much like a detective working through a puzzle.

As you work through this book, you will encounter new concepts, unfamiliar representations, and questions that may not have immediate answers. When this happens, pause and think. Try examples, look for patterns, draw diagrams, discuss with your classmates, and attempt to explain your reasoning. These processes are central to learning mathematics at this level.

Some questions in the book may be accompanied by answers or hints. Even then, you are encouraged to first attempt the problems on your own or with peers. The effort you invest in thinking through a problem will deepen your understanding and make the learning experience more meaningful.

You will notice 'Think and Reflect' questions throughout the textbook. These signal opportunities to explore and think more deeply. Some questions are meant to be discussed with classmates, while others invite creative or extended thinking. Engaging seriously with these will help you develop confidence and flexibility in your mathematical thinking.

At this stage, you will also begin to encounter explanations and justifications that explain why something works, not just how. Do not worry if this takes time to make sense—understanding develops gradually through reflection and discussion.

Most importantly, remember that not understanding something immediately is perfectly normal. Mathematics is learned through persistence, curiosity, and thoughtful engagement. Enjoy the process of figuring things out, and allow yourself the time to grow as a mathematical thinker.

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THE CONSTITUTION OF INDIA

PREAMBLE

WE, THE PEOPLE OF INDIA, having solemnly resolved to constitute India into a ¹**[SOVEREIGN SOCIALIST SECULAR DEMOCRATIC REPUBLIC]** and to secure to all its citizens :

JUSTICE, social, economic and political;

LIBERTY of thought, expression, belief, faith and worship;

EQUALITY of status and of opportunity; and to promote among them all

FRATERNITY assuring the dignity of the individual and the ²[unity and integrity of the Nation];

IN OUR CONSTITUENT ASSEMBLY this twenty-sixth day of November, 1949 do **HEREBY ADOPT, ENACT AND GIVE TO OURSELVES THIS CONSTITUTION.**

1. Subs. by the Constitution (Forty-second Amendment) Act, 1976, Sec.2, for "Sovereign Democratic Republic" (w.e.f. 3.1.1977)
2. Subs. by the Constitution (Forty-second Amendment) Act, 1976, Sec.2, for "Unity of the Nation" (w.e.f. 3.1.1977)