

# MATHEMATICS

*Textbook for Class IX*



0962

विद्यया ऽ मृतमश्नुते



एन सी ई आर टी  
NCERT

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

## 0962 – MATHEMATICS

Textbook for Class 9

ISBN 81-7450-489-3

### First Edition

February 2006 Phalguna 1927

### Reprinted

October 2006, October 2007,  
January 2009, January 2010,  
January 2012, November 2012,  
October 2013, December 2014,  
December 2015, December 2016,  
December 2017, December 2018,  
August 2019, January 2021,  
August 2021, November 2021

### Revised Edition

October 2022 Ashwina 1944

PD 540T BS

© National Council of Educational  
Research and Training, 2006, 2022

₹ 155.00

Printed on 80 GSM paper with NCERT  
watermark

Published at the Publication Division  
by the Secretary, National Council of  
Educational Research and Training, Sri  
Aurobindo Marg, New Delhi 110 016  
and printed at Green World  
Publications (India) Pvt. Ltd., Mander  
Mode, Bamrauli, Allahabad (U.P.)  
211 003

ALL RIGHTS RESERVED

- ❑ No part of this publication may be reproduced, stored in a retrieval system or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording or otherwise without the prior permission of the publisher.
- ❑ This book is sold subject to the condition that it shall not, by way of trade, be lent, re-sold, hired out or otherwise disposed of without the publisher's consent, in any form of binding or cover other than that in which it is published.
- ❑ The correct price of this publication is the price printed on this page. Any revised price indicated by a rubber stamp or by a sticker or by any other means is incorrect and should be unacceptable.

### OFFICES OF THE PUBLICATION DIVISION, NCERT

NCERT Campus  
Sri Aurobindo Marg  
New Delhi 110 016 Phone : 011-26562708

108, 100 Feet Road  
Hosdakere Halli Extension  
Banashankari III Stage  
Bangalore 560 085 Phone : 080-26725740

Navjivan Trust Building  
P.O. Navjivan  
Ahmedabad 380 014 Phone : 079-27541446

CWC Campus  
Opp. Dhankal Bus Stop  
Panihati  
Kolkata 700 114 Phone : 033-25530454

CWC Complex  
Maligaon  
Guwahati 781 021 Phone : 0361-2674869

### Publication Team

Head, Publication : Anup Kumar Rajput  
Division

Chief Production Officer : Arun Chitkara

Chief Business : Vipin Dewan  
Manager

Chief Editor (In charge) : Bijnan Sutar

Production Assistant : Prakash Veer Singh

### Cover and Illustrations

Digital Expressions

## FOREWORD

The National Curriculum Framework (NCF) 2005, recommends that children's life at school must be linked to their life outside the school. This principle marks a departure from the legacy of bookish learning which continues to shape our system and causes a gap between the school, home and community. The syllabi and textbooks developed on the basis of NCF signify an attempt to implement this basic idea. They also attempt to discourage rote learning and the maintenance of sharp boundaries between different subject areas. We hope these measures will take us significantly further in the direction of a child-centred system of education outlined in the national Policy on Education (1986).

The success of this effort depends on the steps that school principals and teachers will take to encourage children to reflect on their own learning and to pursue imaginative activities and questions. We must recognize that, given space, time and freedom, children generate new knowledge by engaging with the information passed on to them by adults. Treating the prescribed textbook as the sole basis of examination is one of the key reasons why other resources and sites of learning are ignored. Inculcating creativity and initiative is possible if we perceive and treat children as participants in learning, not as receivers of a fixed body of knowledge.

This aims imply considerable change in school routines and mode of functioning. Flexibility in the daily time-table is as necessary as rigour in implementing the annual calendar so that the required number of teaching days are actually devoted to teaching. The methods used for teaching and evaluation will also determine how effective this textbook proves for making children's life at school a happy experience, rather than a source of stress or boredom. Syllabus designers have tried to address the problem of curricular burden by restructuring and reorienting knowledge at different stages with greater consideration for child psychology and the time available for teaching. The textbook attempts to enhance this endeavour by giving higher priority and space to opportunities for contemplation and wondering, discussion in small groups, and activities requiring hands-on experience.

The National Council of Educational Research and Training (NCERT) appreciates the hard work done by the textbook development committee responsible for this book. We wish to thank the Chairperson of the advisory group in science and mathematics, Professor J.V. Narlikar and the Chief Advisor for this book, Professor P. Sinclair of IGNOU, New Delhi for guiding the work of this committee. Several teachers contributed

to the development of this textbook; we are grateful to their principals for making this possible. We are indebted to the institutions and organizations which have generously permitted us to draw upon their resources, material and personnel. We are especially grateful to the members of the National Monitoring Committee, appointed by the Department of Secondary and Higher Education, Ministry of Human Resource Development under the Chairpersonship of Professor Mrinal Miri and Professor G.P. Deshpande, for their valuable time and contribution. As an organisation committed to systemic reform and continuous improvement in the quality of its products, NCERT welcomes comments and suggestions which will enable us to undertake further revision and refinement.

New Delhi  
20 December 2005

*Director*  
National Council of Educational  
Research and Training

## RATIONALISATION OF CONTENT IN THE TEXTBOOKS

In view of the COVID-19 pandemic, it is imperative to reduce content load on students. The National Education Policy 2020, also emphasises reducing the content load and providing opportunities for experiential learning with creative mindset. In this background, the NCERT has undertaken the exercise to rationalise the textbooks across all classes. Learning Outcomes already developed by the NCERT across classes have been taken into consideration in this exercise.

### **Contents of the textbooks have been rationalised in view of the following:**

- Overlapping with similar content included in other subject areas in the same class
- Similar content included in the lower or higher class in the same subject
- Difficulty level
- Content, which is easily accessible to students without much interventions from teachers and can be learned by children through self-learning or peer-learning
- Content, which is irrelevant in the present context

*This present edition, is a reformatted version after carrying out the changes given above.*

© NCERT  
not to be republished

## TEXTBOOK DEVELOPMENT COMMITTEE

### CHAIRPERSON, ADVISORY GROUP IN SCIENCE AND MATHEMATICS

J.V. Narlikar, *Emeritus Professor, Chairman*, Advisory Committee, Inter University Centre for Astronomy & Astrophysics (IUCAA), Ganeshkhind, Pune University, Pune

### CHIEF ADVISOR

P. Sinclair, Director, NCERT and *Professor of Mathematics*, IGNOU, New Delhi

### CHIEF COORDINATOR

Hukum Singh, *Professor (Retd.)*, DESM, NCERT

### MEMBERS

A.K. Wazalwar, *Professor and Head*, DESM, NCERT

Anjali Lal, *PGT*, DAV Public School, Sector-14, Gurgaon

Anju Nirula, *PGT*, DAV Public School, Pushpanjali Enclave, Pitampura, Delhi

G.P. Dikshit, *Professor (Retd.)*, Department of Mathematics & Astronomy, Lucknow University, Lucknow

K.A.S.S.V. Kameswara Rao, *Associate Professor*, Regional Institute of Education, Bhubaneswar

Mahendra R. Gajare, *TGT*, Atul Vidyalaya, Atul, Dist. Valsad

Mahendra Shanker, *Lecturer (S.G.) (Retd.)*, NCERT

Rama Balaji, *TGT*, K.V., MEG & Centre, ST. John's Road, Bangalore

Sanjay Mudgal, *Lecturer*, CIET, NCERT

Shashidhar Jagadeeshan, *Teacher and Member*, Governing Council, Centre for Learning, Bangalore

S. Venkataraman, *Lecturer*, School of Sciences, IGNOU, New Delhi

Uday Singh, *Lecturer*, DESM, NCERT

Ved Dudeja, *Vice-Principal (Retd.)*, Govt. Girls Sec. School, Sainik Vihar, Delhi

### MEMBER-COORDINATOR

Ram Avtar, *Professor (Retd.)*, DESM, NCERT (till December 2005)

R.P. Maurya, *Professor*, DESM, NCERT (Since January 2006)

## ACKNOWLEDGEMENTS

The Council gratefully acknowledges the valuable contributions of the following participants of the Textbook Review Workshop: A.K. Saxena, *Professor* (Retd.), Lucknow University, Lucknow; Sunil Bajaj, *HOD*, SCERT, Gurgaon; K.L. Arya, *Professor* (Retd.), DESM, NCERT; Vandita Kalra, *Lecturer*, Sarvodaya Kanya Vidyalaya, Vikas Puri, District Centre, New Delhi; Jagdish Singh, *PGT*, Sainik School, Kapurthala; P.K. Bagga, *TGT*, S.B.V. Subhash Nagar, New Delhi; R.C. Mahana, *TGT*, Kendriya Vidyalaya, Sambalpur; D.R. Khandave, *TGT*, JNV, Dudhnoi, Goalpara; S.S. Chattopadhyay, *Assistant Master*, Bidhan Nagar Government High School, Kolkata; V.A. Sujatha, *TGT*, K.V. Vasco No. 1, Goa; Akila Sahadevan, *TGT*, K.V., Meenambakkam, Chennai; S.C. Rauto, *TGT*, Central School for Tibetans, Mussoorie; Sunil P. Xavier, *TGT*, JNV, Neriya Mangalam, Ernakulam; Amit Bajaj, *TGT*, CRPF Public School, Rohini, Delhi; R.K. Pande, *TGT*, D.M. School, RIE, Bhopal; V. Madhavi, *TGT*, Sanskriti School, Chanakyapuri, New Delhi; G. Sri Hari Babu, *TGT*, JNV, Sirpur Kagaznagar, Adilabad; and R.K. Mishra, *TGT*, A.E.C. School, Narora.

Special thanks are due to M. Chandra, *Professor and Head* (Retd.), DESM, NCERT for her support during the development of this book.

The council acknowledges the valuable inputs for analysing syllabi, textbooks and the content, proposed to be rationalised for this edition by Gupreet Bhatnagar, CBSE Resource Person; Rahul Sofat, CBSE Resource Person; Ashutosh K. Wazalwar, *Professor*, DESM, NCERT and T.P. Sarma, *Professor*, DESM, NCERT.

The Council acknowledges the efforts of *Computer Incharge*, Deepak Kapoor; *D.T.P. Operator*, Naresh Kumar; *Copy Editor*, Pragati Bhardwaj; and *Proof Reader*, Yogita Sharma.

Contribution of APC–Office, administration of DESM, Publication Department and Secretariat of NCERT is also duly acknowledged.



# CONTENTS

FOREWORD	<i>iii</i>
RATIONALISATION OF CONTENT IN THE TEXTBOOKS	<i>v</i>
<b>1. NUMBER SYSTEMS</b>	<b>1</b>
1.1 Introduction	1
1.2 Irrational Numbers	5
1.3 Real Numbers and their Decimal Expansions	8
1.4 Operations on Real Numbers	15
1.5 Laws of Exponents for Real Numbers	21
1.6 Summary	24
<b>2. POLYNOMIALS</b>	<b>25</b>
2.1 Introduction	25
2.2 Polynomials in One Variable	25
2.3 Zeroes of a Polynomial	29
2.4 Factorisation of Polynomials	32
2.5 Algebraic Identities	36
2.6 Summary	42
<b>3. COORDINATE GEOMETRY</b>	<b>43</b>
3.1 Introduction	43
3.2 Cartesian System	46
3.3 Summary	53
<b>4. LINEAR EQUATIONS IN TWO VARIABLES</b>	<b>55</b>
4.1 Introduction	55
4.2 Linear Equations	55
4.3 Solution of a Linear Equation	57
4.4 Summary	59
<b>5. INTRODUCTION TO EUCLID'S GEOMETRY</b>	<b>60</b>
5.1 Introduction	60
5.2 Euclid's Definitions, Axioms and Postulates	62
5.3 Summary	68

<b>6. LINES AND ANGLES</b>	<b>69</b>
6.1 Introduction	69
6.2 Basic Terms and Definitions	70
6.3 Intersecting Lines and Non-intersecting Lines	72
6.4 Pairs of Angles	72
6.5 Lines Parallel to the Same Line	78
6.6 Summary	82
<b>7. TRIANGLES</b>	<b>83</b>
7.1 Introduction	83
7.2 Congruence of Triangles	83
7.3 Criteria for Congruence of Triangles	86
7.4 Some Properties of a Triangle	94
7.5 Some More Criteria for Congruence of Triangles	99
7.6 Summary	103
<b>8. QUADRILATERALS</b>	<b>104</b>
8.1 Properties of a Parallelogram	104
8.2 The Mid-point Theorem	111
8.3 Summary	115
<b>9. CIRCLES</b>	<b>116</b>
9.1 Angle Subtended by a Chord at a Point	116
9.2 Perpendicular from the Centre to a Chord	118
9.3 Equal Chords and their Distances from the Centre	119
9.4 Angle Subtended by an Arc of a Circle	122
9.5 Cyclic Quadrilaterals	125
9.6 Summary	129
<b>10. HERON'S FORMULA</b>	<b>131</b>
10.1 Area of a Triangle – by Heron's Formula	131
10.2 Summary	136
<b>11. SURFACE AREAS AND VOLUMES</b>	<b>137</b>
11.1 Surface Area of a Right Circular Cone	137
11.2 Surface Area of a Sphere	141
11.3 Volume of a Right Circular Cone	145

11.4	Volume of a Sphere	148
11.5	Summary	150
<b>12.</b>	<b>STATISTICS</b>	<b>151</b>
12.1	Graphical Representation of Data	151
12.2	Summary	166
<b>APPENDIX – 1</b>	<b>PROOFS IN MATHEMATICS</b>	<b>167</b>
A1.1	Introduction	167
A1.2	Mathematically Acceptable Statements	168
A1.3	Deductive Reasoning	171
A1.4	Theorems, Conjectures and Axioms	174
A1.5	What is a Mathematical Proof?	179
A1.6	Summary	186
<b>APPENDIX – 2</b>	<b>INTRODUCTION TO MATHEMATICAL MODELLING</b>	<b>187</b>
A2.1	Introduction	187
A2.2	Review of Word Problems	188
A2.3	Some Mathematical Models	192
A2.4	The Process of Modelling, its Advantages and Limitations	200
A2.5	Summary	203
<b>ANSWERS/HINTS</b>		<b>205-219</b>

# THE CONSTITUTION OF INDIA

## PREAMBLE

**WE, THE PEOPLE OF INDIA**, having solemnly resolved to constitute India into a <sup>1</sup>**[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 <sup>2</sup>[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)