

MATHEMATICS

Textbook for Class IX



0962



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

ISBN 81-7450-489-3

First Edition

February 2006 Phalguna 1927

Reprinted

October 2006 Kartika 1928

October 2007 Kartika 1929

January 2009 Magha 1930

January 2010 Pausa 1931

January 2012 Magha 1933

November 2012 Kartika 1934

October 2013 Kartika 1935

December 2014 Pausa 1936

December 2015 Agrahayana 1937

December 2016 Pausa 1938

December 2017 Pausa 1939

December 2018 Agrahayana 1940

August 2019 Shravana 1941

PD 750T BS

© National Council of Educational
Research and Training, 2006

₹ 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
110016 and printed at Nova
Publications & Printers Pvt. Ltd., Plot
No. 9-10, Sector-59, Phase-II,
Faridabad-121 004 (Haryana)

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 Division : M. Siraj Anwar

Chief Editor : Shveta Uppal

Chief Production Officer : Arun Chitkara

Chief Business Manager : Bibash Kumar Das

Editor : Bijnan Sutar

Production Assistant : Sunil Kumar

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

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

Uaday 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 Vidyalya, 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 Vidyalya, 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 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	iii
1. NUMBER SYSTEMS	1
1.1 Introduction	1
1.2 Irrational Numbers	5
1.3 Real Numbers and their Decimal Expansions	8
1.4 Representing Real Numbers on the Number Line	15
1.5 Operations on Real Numbers	18
1.6 Laws of Exponents for Real Numbers	24
1.7 Summary	27
2. POLYNOMIALS	28
2.1 Introduction	28
2.2 Polynomials in One Variable	28
2.3 Zeroes of a Polynomial	32
2.4 Remainder Theorem	35
2.5 Factorisation of Polynomials	40
2.6 Algebraic Identities	44
2.7 Summary	50
3. COORDINATE GEOMETRY	51
3.1 Introduction	51
3.2 Cartesian System	54
3.3 Plotting a Point in the Plane if its Coordinates are given	61
3.4 Summary	65
4. LINEAR EQUATIONS IN TWO VARIABLES	66
4.1 Introduction	66
4.2 Linear Equations	66
4.3 Solution of a Linear Equation	68
4.4 Graph of a Linear Equation in Two Variables	70
4.5 Equations of Lines Parallel to x -axis and y -axis	75
4.6 Summary	77

5.	INTRODUCTION TO EUCLID'S GEOMETRY	78
5.1	Introduction	78
5.2	Euclid's Definitions, Axioms and Postulates	80
5.3	Equivalent Versions of Euclid's Fifth Postulate	86
5.4	Summary	88
6.	LINES AND ANGLES	89
6.1	Introduction	89
6.2	Basic Terms and Definitions	90
6.3	Intersecting Lines and Non-intersecting Lines	92
6.4	Pairs of Angles	92
6.5	Parallel Lines and a Transversal	98
6.6	Lines Parallel to the same Line	101
6.7	Angle Sum Property of a Triangle	105
6.8	Summary	108
7.	TRIANGLES	109
7.1	Introduction	109
7.2	Congruence of Triangles	109
7.3	Criteria for Congruence of Triangles	112
7.4	Some Properties of a Triangle	120
7.5	Some More Criteria for Congruence of Triangles	125
7.6	Inequalities in a Triangle	129
7.7	Summary	134
8.	QUADRILATERALS	135
8.1	Introduction	135
8.2	Angle Sum Property of a Quadrilateral	136
8.3	Types of Quadrilaterals	137
8.4	Properties of a Parallelogram	139
8.5	Another Condition for a Quadrilateral to be a Parallelogram	145
8.6	The Mid-point Theorem	148
8.7	Summary	151
9.	AREAS OF PARALLELOGRAMS AND TRIANGLES	152
9.1	Introduction	152
9.2	Figures on the same Base and Between the same Parallels	154

9.3	Parallelograms on the same Base and between the same Parallels	156
9.4	Triangles on the same Base and between the same Parallels	160
9.5	Summary	167
10.	CIRCLES	168
10.1	Introduction	168
10.2	Circles and its Related Terms : A Review	169
10.3	Angle Subtended by a Chord at a Point	171
10.4	Perpendicular from the Centre to a Chord	173
10.5	Circle through Three Points	174
10.6	Equal Chords and their Distances from the Centre	176
10.7	Angle Subtended by an Arc of a Circle	179
10.8	Cyclic Quadrilaterals	182
10.9	Summary	187
11.	CONSTRUCTIONS	187
11.1	Introduction	188
11.2	Basic Constructions	189
11.3	Some Constructions of Triangles	191
11.4	Summary	196
12.	HERON'S FORMULA	197
12.1	Introduction	197
12.2	Area of a Triangle – by Heron's Formula	199
12.3	Application of Heron's Formula in finding Areas of Quadrilaterals	203
12.4	Summary	207
13.	SURFACE AREAS AND VOLUMES	208
13.1	Introduction	208
13.2	Surface Area of a Cuboid and a Cube	208
13.3	Surface Area of a Right Circular Cylinder	214
13.4	Surface Area of a Right Circular Cone	217
13.5	Surface Area of a Sphere	222
13.6	Volume of a Cuboid	226
13.7	Volume of a Cylinder	228

13.8	Volume of a Right Circular Cone	231
13.9	Volume of a Sphere	234
10.10	Summary	237
14.	STATISTICS	238
14.1	Introduction	238
14.2	Collection of Data	239
14.3	Presentation of Data	240
14.4	Graphical Representation of Data	247
14.5	Measures of Central Tendency	261
14.6	Summary	270
15.	PROBABILITY	271
15.1	Introduction	271
15.2	Probability – an Experimental Approach	272
15.3	Summary	285
APPENDIX – 1	PROOFS IN MATHEMATICS	286
A1.1	Introduction	286
A1.2	Mathematically Acceptable Statements	287
A1.3	Deductive Reasoning	290
A1.4	Theorems, Conjectures and Axioms	293
A1.5	What is a Mathematical Proof?	298
A1.6	Summary	305
APPENDIX – 2	INTRODUCTION TO MATHEMATICAL MODELLING	306
A2.1	Introduction	306
A2.2	Review of Word Problems	307
A2.3	Some Mathematical Models	311
A2.4	The Process of Modelling, its Advantages and Limitations	319
A2.5	Summary	322
ANSWERS/HINTS		325-350