SINDH CURRICULUM FOR

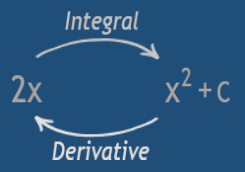
MATHEMATICS

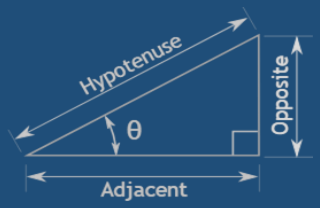
GRADE IX TO XII 2024

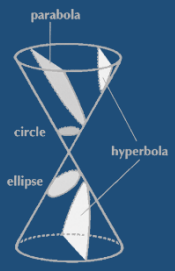
$$\sin\theta = \frac{Opposite}{Hypotenuse}$$

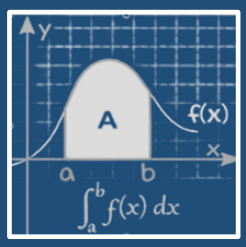
$$Cos\,\theta = \frac{Adjacent}{Hypotenuse}$$

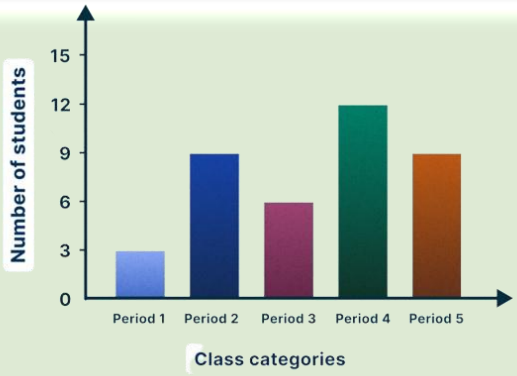
$$\tan\theta = \frac{Opposite}{Adjacent}$$

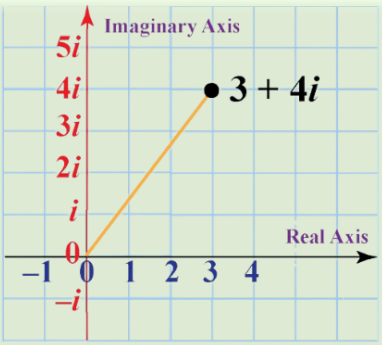


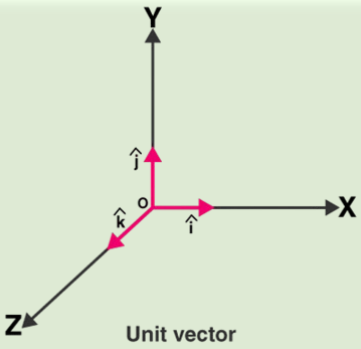












GOVERNMENT OF SINDH

SCHOOL EDUCATION & LITERACY DEPARTMENT

DIRECTORATE OF CURRICULUM, ASSESSMENT & RESEARCH SINDH JAMSHORO

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INTRODUCTION

Mathematics and Mathematics Teaching

The Sindh curriculum is based on the notion that mathematics promotes logical reasoning and intellectual rigour and is essential for understanding the content of other academic disciplines. This viewpoint emphasises active interactions between the teacher and the students, between the students and mathematical concepts, and between mathematics and other disciplines. Active interactions place a stronger emphasis on investigations and problem solving, which leads to learners developing mathematical comprehension, critical thinking, invention, and logic abilities. Mathematics, in nature, provides science and other disciplines with interesting problems to investigate and tools to discover and analyse the data.

This curriculum contains the mathematical concepts, learning objectives, and activities for Grades IX through XII, must be understood as a well-designed educational plan. It serves as a roadmap for both instructors and students, guaranteeing a well-organized, sequential, and complete learning process with objectives that promote skill development, critical thinking, and in-depth topic mastery. It is designed with the goal of producing knowledgeable, competent, and adaptive persons in pupils by taking into account shifting educational requirements, cultural realities, and a dynamic and stimulating learning environment. With the goal of assisting students in exploring the interdisciplinary nature of mathematics and its applications across the disciplines, the curriculum's design incorporates the integration of Science, Technology, Engineering, Arts, and Mathematics (STEAM).

The curriculum emphasises that mathematics education is much more than simply delivering a set of rules and proofs; it must be meaningful to be remembered, coherent to be understood, planned to be continuous, and enjoyable to be sustained for the rest of one's life. According to the curriculum, mathematics teachers' responsibility is to guarantee that pupils study mathematics in meaningful ways while also developing logical, rational, and independent learning skills. Because mathematics is an exploratory and investigative topic, competent mathematics teachers consistently demand and strive for the best learning outcomes for their students, thereby assisting them in developing life skills. Hence, a mathematics teacher's role is to facilitate and stimulate student learning by planning rich mathematical tasks, posing interesting questions, providing situations for encouraging justifications, and challenging students' ideas to help them develop conceptual understanding and logical thinking skills. A mathematics instructor must actively consider students' affective (emotional) and cognitive (intellectual) development by establishing a social, dynamic environment for studying mathematics rather than simply giving them a fixed set of facts. This curriculum implies that in mathematics, a teacher must invite student participation, grasp their level of thinking, assign relevant and rich tasks, and assess the results, using alternative assessment methods, of those tasks to understand how students construct meanings. This is opposed to established teaching methods. In this way, a mathematics teacher transitions from dispensing information to planning investigative tasks, managing a cooperative learning environment, and encouraging students' creativity in the construction of mathematical knowledge and achieving a common, agreed-upon mathematical interpretation through a variety of methods.

Note; The Sindh Curriculum 2024 for mathematics for grade IX to XII, is based on adopted minimum standards of Nation Curriculum of Pakistan 2023.

Cross Cutting Themes

The idea of Science, Technology, Engineering, Arts and Mathematics (STEAM) is an overarching idea for how to break up the study of Math into core disciplinary knowledge (that students need to learn in order to pass examination at each grade level) and cross cutting themes (interdisciplinary connections and recurring ideas that are best reinforced in every chapter in order to promote student critical thinking and curiosity).

Cross-cutting themes must be appropriately included into every chapter of schools textbooks that are aligned with these standards. This does not mean that every subcomponent of every theme must be included in every chapter, rather than where connections are appropriate and would enhance the study of the core disciplinary knowledge these should be incorporated.

Science, Technology and Engineering: applications of mathematics to create solutions that improve standards of living and the connections of mathematics with the natural world.

Arts: What can be understood about the nature of mathematics from the fine arts, performing arts and the humanities?

Mathematics: theoretical understandings /big ideas in mathematics and mathematical practices, and their mutual overlaps in the methods of mathematical inquiry.

Science, Technology and Engineering
Applications of Mathematics:
The interconnectedness of Mathematics and Science • The symbolic language of mathematics is extremely valuable for expressing scientific ideas unambiguously. • Mathematics provides the rules for analysing scientific ideas and data rigorously. • The accuracy and reliability of mathematical theories and principles serve as a basis for scientific discovery and understanding. • Science provides mathematics with interesting problems to investigate, and mathematics provides science with powerful. • Mathematics has a wide range of applications in science, engineering and technology. • Mathematics is often used as a tool in the sciences, such as physics, chemistry, and biology, to describe and explain phenomena in the natural world. • Mathematical models and equations are used to make predictions and test hypotheses in scientific research. • Engineers use mathematical concepts and techniques to solve practical problems and design systems and structures. • Engineers use mathematical models to simulate and analyse the behaviour of systems, and to optimise their designs. • Engineers also use mathematical tools to analyse and control complex systems and processes. • Mathematical methods and techniques are used to analyse and optimise the performance of a wide variety of technological systems and devices, including communication systems, control systems, and manufacturing processes.

Arts

Nature of Mathematics

1. Mathematics is a product of the exploration of structure, patterns and relationships.

- As a theoretical discipline, mathematics is driven by abstract concepts and generalisation. This mathematics is drawn out of ideas, and develops through linking these ideas and developing new ones.
- As an applied discipline, mathematicians focus their attention on solving problems and discovering relationships that originate in the world of experience.
- The result of theoretical and applied mathematics often influences each other.

2. Mathematics uses a variety of methods to make claims.

- Mathematics uses multiple strategies and multiple representations to revise and produce new knowledge.
- The new knowledge is presented in the form of theorems that have been built from axioms and logical mathematical arguments and a theorem is only accepted as true when it has been proven.
- Mathematics relies on logic rather than on observation as its standard of validity and accuracy, yet employs observation, simulation, and even experimentation as means of discovering new ideas, theories and principles.

3. Mathematical knowledge is open to revision and refinement.

- Mathematics has a history that includes the refinement of, and changes to, theories, ideas, and beliefs over time.
- Mathematics is critiqued and verified by people within particular cultures through justification or proof that is communicated to oneself and others.
- The body of knowledge that makes up mathematics is not fixed; it has grown during human history and is growing at an increasing rate.

4. Mathematics is a human endeavour.

- Mathematical knowledge is a result of human endeavour, imagination and creativity.
- Mathematics can be produced by each and every person.
- Mathematics is not created arbitrarily, but arises from activity with already existing mathematical objects, and from the needs of science and daily life.
- Individuals and teams from many nations and cultures have contributed to mathematics and to advances in mathematical applications in science engineering and technology.
- Mathematicians' background, theoretical commitments, and fields of endeavour influence the nature of their findings.
- Technological advances have influenced the progress of mathematics and mathematics has influenced in advances.
- Mathematical ideas impact society and culture, and cultural and societal factors influence the development of mathematics.

5.Mathematics is worthwhile, beautiful and often useful.

- Mathematics today is a diverse discipline that deals with data, measurements, and observations from science; with inference, deduction and proof; and with mathematical models of natural phenomena, of human behaviour, and of social systems.

- Mathematics empowers us to better understand the information-laden world in which we live by equipping us with critical thinking skills.
- Mathematics reveals hidden patterns that help us understand the natural world around us.
- The patterns and structures that exist in mathematics are considered to be aesthetically pleasing and beautiful, much like works of art.
- Mathematics is a language that is understood and used globally, making it a bridge between cultures and disciplines.

Mathematics

Mathematical knowledge (these themes represent big ideas in mathematics which are applied across the conceptual SLOs)

Quantity, Measurement and Approximation

- Quantities and values can be used to describe key features and behaviours of objects such as functions.
- Measurement can be represented in equivalent ways using different units. For example, degrees and radians can be used for angles to facilitate ease of calculation.
- Approximation of numbers adds uncertainty or inaccuracy to calculations, leading to potential errors but can be useful when handling extremely large or small quantities.
- When quantities change, a useful measurement to make is the "Rate of Change" which gives us an idea of how much one quantity is dependent on the other.

Abstraction and Generalization

- Mathematical situations and structures can be translated and represented abstractly using variables, expressions, and equations.
- Extending results from a specific case to a general form can allow us to apply them to a larger system.

Patterns, Relationships and Modelling systems

- Patterns can be identified in behaviours which can give us insight into appropriate strategies to model or solve them.
- Relationships can be described and generalizations made for mathematical situations that have numbers or objects that repeat in predictable ways.
- Modelling real-life situations allows for prediction, analysis and interpretation and can be used to provide effective problems.
- Predictions based on models have limited precision and reliability due to the assumptions and approximations inherent in models.

Representation and Equivalence

- Any number, measure, numerical expression, algebraic expression, or equation can be represented in an infinite number of ways that have the same value.
- Different but equivalent representations of objects such as visual, symbolic, verbal, contextual and physical representations can different characteristics of the same relationship.
- Different representations enable quantities to be compared and used for computational purposes with ease and accuracy.

Space

- Objects in space can be oriented in an infinite number of ways, and an object's location in space can be described quantitatively.
- Objects in space can be transformed in an infinite number of ways, and those transformations can be described and analyzed mathematically.

Logic, Validity and Justification

- Logic is a powerful tool for justifying what we discover through measurement and observation.
- Logic is a method of reasoning and a system of principles used to build arguments, reach conclusions and explain the validity of these conclusions.
- Considering reasonableness and validity of results helps us to make informed, unbiased decisions.

Mathematical Practice (these themes are also embedded in the conceptual SLOs but will primarily be implemented through teaching and learning practices elaborated in this curriculum guide)

Problem-solving

- Understand the meaning of a problem and look for entry points to its solution.
- Analyze givens, constraints, relationships, and goals.
- Make conjectures about the form and meaning of the solution and plan a solution pathway.
- Employ different problem-solving strategies in order to gain insight into its solution.

These can include:

- Considering analogous problems.
- Trying special cases and simpler forms of the original problem.
- Finding patterns or structure and looking for general methods.
- Listing all possibilities and eliminating options based on constraints.
- Making educated guesses and using trial and error.
- Visualising the problem using different diagrams.
- Working backwards.
- Monitor and evaluate progress and check answers to problems using a different method.
- Understand the aches of others to solving complex problems and identify correspondences between different approaches.

Communication and reasoning

- While constructing arguments, understand and use stated assumptions, clear definitions, and previously established results, considering the unit involved and attending to the meaning of quantities and symbols.
- Make conjectures and build a logical progression of statements to explore the truth of the conjectures.
- Analyse situations by breaking them into cases, and recognize and use counterexamples.
- Justify conclusions, communicate them to others, and respond to the arguments of others.
- Ask useful questions to clarify or improve the arguments.

- Compare the effectiveness of two plausible arguments, distinguish correct logic or reasoning from that which is flawed, and explain the flaw in an incorrect argument.

Mathematical modelling

- Apply mathematical knowledge to solve problems arising in everyday life, society, and the workplace.
- Make choices, assumptions and approximations to simplify a complicated situation.
- Identify variables in the situation and select those that represent essential features.
- Formulate a model by creating and selecting geometric, graphical, tabular, algebraic, or statistical representations that describe relationships between the variables.
- Analyse these relationships mathematically to draw conclusions.
- Interpret the mathematical results in the context of the original situation.
- Validate the conclusion by comparing them with the situation, and improve the model if it has not served its purpose.s

Use appropriate tools strategically

- Able to use tools including technological tools, to explore and deepen their understanding of concepts, solve mathematical problems, test conjectures justify interpretations.
- Be familiar with the different kinds of non-technological tools available such as pencil and paper, concrete models, ruler, protector and calculator.
- Be familiar with the different kinds of technological tools available such as graphical calculators, dynamic graphing, software, spreadsheet, simulations, apps, and dynamic geometry software.
- Make sound decisions about when each of these tools might be helpful, recognizing both the insight to be gained and their limitations.

PROGRESSION GRID

Domain A: Numbers and Algebra

Number system is a system of representing numbers in mathematics. Students deal with various types of numbers for solving mathematics formulas and calculation, data processing and handling complex topics like algebra and geometry.

Algebra is one of the oldest branches in the history of mathematics that deals with number theory, geometry, and analysis. It is the study of mathematical symbols and the rules for manipulating these symbols in formulas; it is a unifying thread of almost all of mathematics. Algebra includes almost everything right from solving elementary equations to the study of abstractions. Also there are several algebra equations, formulas and identities present in algebra

Standards:

- Compare the properties of numbers and number systems, including the rational and real numbers, and understand complex numbers as solutions of quadratic equations that do not have real solutions.
- Understand vectors and matrices as systems that have some of the properties of the real number system.
- Use number-theory arguments to justify relationships involving whole number.
- Analyse and interpret mathematical situations by manipulating algebraic expressions and relations.
- Model and solve contextual problems.
- Interpret functions, calculate rate of change of functions, apply differentiation, integrate analytically.
- Utilize integration, solve simple ordinary differential equations, solve nonlinear equations numerically by simple iterative formula.

Benchmarks (Grade IX – X)	Benchmarks (Grade XI – XII)
Benchmark I: Students will be able to identify real and complex numbers and their properties to carry out basic operations. **Benchmark II:** Students will be able to add, subtract, and multiply matrices, evaluate the determinant of matrices to find the inverse of matrices, solve simultaneous linear equations using matrices. **Benchmark III:** Students will be able to use venn diagrams to demonstrate and describe operations of sets and apply in real life situations. Express functions, inverse functions, and composite functions. Benchmark IV: Students will be able to simplify, factorise and manipulate algebraic fractions. Identify and rationalise surds, and factorise algebraic expressions. **Benchmark V:** Students will be able to solve linear equations, a system of two linear equations with two variables and solve linear inequalities.	**Benchmark I:** Students will be able to Identify complex numbers and their properties to carry out basic operations. **Benchmark II:** Students will be able to perform matrix algebra, evaluate determinant and solve homogeneous and non-homogeneous linear equations. **Benchmark III:** Students will be able to demonstrate Arithmetic, geometric and harmonic sequence, their means and sum of series and apply them in real world problems. **Benchmark IV:** Students will be able to apply the principle of Mathematical Induction to prove statements, identities, and formulae, and find approximate values of the binomial expansions having indices as rational numbers. **Benchmark V:** Students will be able to divide polynomials, apply factor theorem, remainder theorem, factorise cubic polynomial and resolve an algebraic fraction into partial fractions

Benchmark VI: Students will be able to solve quadratic equations by using different methods and solve real world situations by formulating a quadratic equation. **Benchmark VII:** Students will be able to plot and interpret the graphs in practical situations such as travel graphs, conversions graphs and peed time graphs.	**Benchmark VI:** Students will be able to analyse attributes of quadratic equations and solve quadratic equations, and quadratic inequalities, in one unknown. **Benchmark VII:** Students will be able to plot and interpret the Graphs of functions. Fundamental transcendental functions, their domain and range. Evaluate limits of different algebraic, exponential, and trigonometric functions. **Benchmark VIII:** Students will be able to differentiate and integrate a scalar and vector functions with the emphasis on practical applications. **Benchmark IX:** Students will be able to find Solution of differential equations and apply first-order separable ordinary differential equations of degree one. **Benchmark X:** Students will be able to solve nonlinear equations in one variable and definite integral by numerical methods.

Student Learning Outcomes (SLOs)			
Grade-IX	**Grade-X**	**Grade-XI**	**Grade-XII**
Real Numbers **[SLO:M-09-A-01]:** Describe the set of real numbers as a combination of rational and irrational numbers. **[SLO:M-09-A-02]:** Explain and verify the properties of equality and inequality of real numbers. **[SLO:M-09-A-03]:** Apply laws of indices to simplify radical expressions. **[SLO:M-09-A-04]:** Express a number in scientific notations and vice versa. **[SLO:M-09-A-05]:** Define logarithm of a number.	**Complex Number** **[SLO:M-10-A-01]:** Identify a complex number (z), complex conjugate ($\bar{z}$), absolute value or modulus ($\|z\|$) of a complex number. **[SLO:M-10-A -02]:** Apply algebraic properties and perform basic operations on complex numbers z. **[SLO:M-10-A-03]:** Demonstrate additive identity and multiplicative identity for the set of complex numbers z. **[SLO:M-10-A-04]:** Find additive inverse and multiplicative inverse of a complex number z. **[SLO:M-10-A-05]:** Demonstrate the following properties of a complex number z.	**Complex Number** **[SLO:M-11-A-01]:** Define $z = a - ib$ as the complex conjugate of $z = a + ib$ **[SLO:M-11-A-02]:** Define $\|z\| = \sqrt{a^2 + b^2}$ as the absolute value or modulus of a complex number z = a + ib. **[SLO:M-11-A-03]:** Examine the condition for equality of complex numbers. **[SLO:M-11-A-04]:** Perform basic operations on complex numbers. **[SLO:M-11-A-05]:** Verify triangle inequality of complex numbers. **[SLO:M-11-A-06]:** Represent complex number to argand diagram, complex or z-plane.	

Student Learning Outcomes (SLOs)			
Grade-IX	**Grade-X**	**Grade-XI**	**Grade-XII**
[SLO:M-09-A-06]: Laws of logarithm. **[SLO:M-09-A-07]:** Apply laws of logarithm to real life situations such as growth and decay, loudness of sound. **[SLO:M-09-A-08]:** Apply concepts of rational numbers to real word problems (such as inventory, temperature, banking, measures of gain and loss, source of income and expenditure).	• $\|z\|=\|-z\|=\|\bar{z}\|=\|-\bar{z}\|$ • $z.\bar{z} = \|z\|^2$ • $\|\overline{z_1.z_2}\| = \bar{z}_1.\bar{z}_2$ • $\left(\frac{z_1}{z_2}\right) = \frac{\bar{z}_1}{\bar{z}_2}$, $z_2 \neq 0$ **[SLO:M-10-A-06]:** Find real and imaginary parts of complex numbers of the type, $(x+iy)^n$, $[\frac{x_1+iy_1}{x_2+iy_2}]^n$, $x_2 + iy_2 \neq 0$ Where n = ± 1 *and* ± 2 **[SLO:M-10-A-07]:** Solve the simultaneous linear equations with complex coefficients. **[SLO:M-10-A-08]:** Apply the geometric interpretation of a complex number. **[SLO:M-10-A-09]:** Apply the geometric interpretation of the modulus of a complex number. **[SLO:M-10-A-10]:** Apply the geometric interpretation of algebraic operations.	**[SLO:M-11-A-07]** Solve the simultaneous linear equations with complex coefficients. For example, $5z - (3+i)w = 7 - i$ $(2-i)z + 2iw = -1 + i$ **[SLO:M-11-A-08]:** Write the polynomial P(z) as a product of linear factors. For example, $z^2 + a^2 = (z + ia)$ *(z – ia)* $z^3 - 3z^2 + z + 5 =$ *(z + 1)(z -2 – i) (z -2 + i)* **[SLO:M-11-A-09]:** Solve quadratic equation of the form $pz^2 + qz + r = 0$ by completing squares, where *p, q, r* are real numbers and *z* is a complex number. **[SLO:M-11-A-10]:** Explain the polar coordinates system. **[SLO:M-11-A-11]:** Describe the polar representation of a complex number. **[SLO:M-11-A-12]:** Apply the operations with complex numbers in a polar representation. **[SLO:M-11-A-13]:** State De-Moivre's theorem and its use. **[SLO:M-11-A-14]:** Demonstrate simple equations and in-equations involving complex numbers in polar form.	

Student Learning Outcomes (SLOs)			
Grade-IX	**Grade-X**	**Grade-XI**	**Grade-XII**
		[SLO:M-11-A-15]: Apply concepts of complex numbers to solve real-life problems (such as cryptography, wave phenomena, calculates voltage, current, circuits, the velocity and pressure of the fluid).	
	Matrices and determinants **[SLO:M-10-A-11]:** Introduce the concept of matrix and its type (row, column, rectangular, square, zero/null, diagonal, scalar and identity/unit matrix) of order 2x2. **[SLO:M-10-A-12]:** Solve situations involving sum, difference, and product of two matrices. **[SLO:M-10-A-13]:** Calculate the product of the scalar quantity and a matrix. **[SLO:M-10-A-14]:** Evaluate the determinant and inverse of a matrix of order 2x2. **[SLO:M-10-A-15]:** Solve the simultaneous linear equations in two variables using matrix inversion method and Cramer's rule **[SLO:M-10-A-16]:** Apply concepts of matrices to solve real-life problems (such as engineering, economics, and physics).	**Matrices & Determinants** **[SLO:M-11-A-16]:** Apply matrix operations (addition/subtraction and multiplication of matrices) with real and complex entries. **[SLO:M-11-A-17]:** Explain types of matrices (including, symmetric, skew-symmetric, Hermitian, skew-Hermitian, periodic, idempotent, involutory and nilpotent matrix) **[SLO:M-11-A-18]:** Show that in matrix algebra commutative law: • holds under addition, i.e. $A + B = B + A$ • does not hold under multiplication i.e. $AB \neq BA$, in general. **[SLO:M-11-A-19]:** Define minors and cofactors, and use them to evaluate the determinants of 3×3. **[SLO:M-11-A-20]:** State properties of determinants, and use them to evaluate the determinants of 3×3. **[SLO:M-11-A-21]:** Define elementary row operations, echelon and reduced echelon form of	

Student Learning Outcomes (SLOs)			
Grade-IX	**Grade-X**	**Grade-XI**	**Grade-XII**
		a matrix, and use them to find the inverse and the rank of a matrix. **[SLO:M-11-A-22]:** Solve a system of 3×3 non-homogeneous linear equations by using matrix inversion method and Cramer's rule. **[SLO:M-11-A-23]:** Solve a system of three homogeneous linear equations in three unknowns using the Gauss elimination method and Gauss-Jordan method. **[SLO:M-11-A-24]:** Explain a consistent and inconsistent system of linear equations and demonstrate through examples. **[SLO:M-11-A-25]:** Apply concepts of matrices to solve real-life problems such as (graphic design, data encryption, seismic analysis, cryptography, transformation of geometric shapes, social network analysis).	
Sets and Functions **[SLO:M-09-A-09]:** Identify sets and apply operations on three sets (subsets, overlapping sets and disjoint sets), using venn diagram. **[SLO:M-09-A-10]:** Verify and apply properties/laws of union and intersection of three sets through analytical and venn diagram methods.	**Functions and Graphs** **[SLO:M-10-A-17]:** Recognize notation and determine the value of a function. **[SLO:M-10-A-18]:** Identify types of functions (into, onto/ surjective, one-to-one/ injective, and bijective) by using diagrams. **[SLO:M-10-A-19]:** Explain algebraic operations on functions.		**Functions and Graphs** **[SLO:M-12-A-01]:** Define function, domain, co-domain, range of a function, one-to-one (injective), onto (surjective), and bijective functions. **[SLO:M-12-A-02]:** Explain constant, linear, quadratic, square root, reciprocal and modulus/absolute value functions.

Student Learning Outcomes (SLOs)			
Grade-IX	**Grade-X**	**Grade-XI**	**Grade-XII**
[SLO:M-09-A-11]: Apply concepts from set theory to real-life problems (such as in demographic classification, categorizing products in shopping malls and music playlist by genre). **[SLO:M-09-A-12]:** Examine cartesian product, binary relations and its domain and range. **[SLO:M-09-A-13]:** Examine that a relation can be represented by table, order pair and graphs. **[SLO:M-09-A-14]:** Define the concept of function with examples.	**[SLO:M-10-A-20]:** Explain and formulate composite functions as defined by fog(x) = f(g(x)) and gof(x) = g(f(x)) **[SLO:M-10-A-21]:** Find the inverse of a given function. **[SLO:M-10-A-22]:** Apply concepts from functions to real world problems (such as finance, transportation, and sales). **[SLO:M-10-A-23]:** Plot graphs of constant function, identity function, linear function and absolute-valued functions. **[SLO:M-10-A-24]:** Solve absolute-valued equations and inequalities in one variable and express the solution as a range of values on a number line. **[SLO:M-10-A-25]:** Apply concepts of absolute-valued functions to solve real-life problems (including physics and engineering).		**[SLO:M-12-A-03]:** Define inverse functions and identify their domain and range with examples. **[SLO:M-12-A-04]:s** Sketch graphs of: • constant functions ($y = c$, c is a real number) • linear functions (e.g. $y = ax + b$), • non-linear functions; $y = x^n$ where n is an integer, $(x \neq 0)$; and n is a rational number for $x > 0$ • Quadratic functions for example $y = ax^2 + bx + c$ where a, b, c are real numbers $(a \neq 0)$; **[SLO:M-12-A-05]:** Draw the graph of modulus/absolute value function. **[SLO:M-12-A-06]:** Represent the relation between bijective function and its inverse through graph. **[SLO:M-12-A-07]:** Draw graph of quadratic functions using factors. **[SLO:M-12-A-08]:** Identify functions from their graphs; use the factor form to identify the equation of a function of the type: $f(x) = ax^2 + bx + c$ **[SLO:M-12-A-09]:** Find the intersecting point graphically when intersection occurs between: • a linear function and coordinate axes

Student Learning Outcomes (SLOs)			
Grade-IX	**Grade-X**	**Grade-XI**	**Grade-XII**
			• two linear functions • a linear and a quadratic function. **[SLO:M-12-A-10]:** Solve real-life problems graphically. **[SLO:M-12-A-11]:** Define transcendental functions and describe various transcendental functions such as: • Trigonometric functions • Inverse trigonometric functions • Logarithmic function • Exponential function **[SLO:M-12-A-12]:** Identify the domain and range of fundamental transcendental functions. **[SLO:M-12-A-13]:** Classify the algebraic and transcendental functions. **[SLO:M-12-A-14]:** Sketch the graphs of exponential and logarithmic functions and analyse. **[SLO:M-12-A-15]:** Apply the concept of exponential function to solve real-life problems i.e. finding bacterial growth/decay, banking and accounting. **[SLO:M-12-A-16]:** Demonstrate the transformations of a graph through horizontal shift, vertical shift, and scaling.

Student Learning Outcomes (SLOs)			
Grade-IX	**Grade-X**	**Grade-XI**	**Grade-XII**
			Limit and Continuity of a Function **[SLO:M-12-A-17]:** Define and find the limit of a sequence. **[SLO:M-12-A-18]:** Define and find the limit of a function when: • $x \to 0$ • $x \to a$ • $x \to \pm\infty$ **[SLO:M-12-A-19]:** State and apply theorems on limit of sum, difference, product and quotient of functions to algebraic, exponential, logarithmic and trigonometric functions. **[SLO:M-12-A-20]:** Define left and right hand limits with examples. **[SLO:M-12-A-21]:** Examine continuity and discontinuity of a function at a point. **[SLO:M-12-A-22]:** Apply concepts of limit of functions and continuity to solve real-life problems (such as growth and decay, mechanics, finance, economics and predicting long-term stock prices). **Introduction to Differentiation** **[SLO:M-12-A-23]:** Define increment and decrement with examples also average and instantaneous rates of a function. **[SLO:M-12-A-24]:** Define meaning of derivative as a rate of change and as a slope of a tangent line.

Student Learning Outcomes (SLOs)			
Grade-IX	**Grade-X**	**Grade-XI**	**Grade-XII**
			[SLO:M-12-A-25]: Find the derivative of various algebraic and transcendental functions by ab-initio/first principle method such as: • Power function • Trigonometric functions • Inverse trigonometric functions • Exponential functions • Logarithmic functions **[SLO:M-12-A-26]:** State, prove and apply rules of derivative such as: • Scalar multiplication rule • Sum and difference rules • Product rule • Quotient rule • Chain rule **[SLO:M-12-A-27]:** Explain with examples: • logarithmic differentiation • implicit differentiation • parametric differentiation **[SLO:M-12-A-28]:** State the connection between continuity and derivatives. **[SLO:M-12-A-29]:** Find higher order derivatives (up to 4^{th} order) of functions such as: • Algebraic e.g. $y = (ax + b)^m$, where m is a +ve integer; and $y = \frac{1}{ax + b}$

Student Learning Outcomes (SLOs)			
Grade-IX	**Grade-X**	**Grade-XI**	**Grade-XII**
			• Trigonometric e.g. $y = \sin(ax + b)$ *and* $y = \cos(ax + b)$ • Logarithmic function e.g. $y = ln(ax + b)$ • Exponential function e.g. $y = e^{ax+b}$ **Applications of derivatives** **[SLO:M-12-A-30]:** Calculate rate of change of displacement, velocity and acceleration of an object moving along a straight line. **[SLO:M-12-A-31]:** Use derivatives to find equations of tangent and normal to a curve at a point. **[SLO:M-12-A-32]:** Explain differentials and related applications. **[SLO:M-12-A-33]:** Calculate the relative error and percentage error by using differential approximation. (e.g. area and volume) **[SLO:M-12-A-34]:** Explain the increasing and decreasing functions by using derivatives. **[SLO:M-12-A-35]:** Illustrate stationary/critical points, inflection points, global extrema (absolute extrema) and local extrema (relative extrema). **[SLO:M-12-A-36]:** Find the extreme values by applying the second derivative test.

Student Learning Outcomes (SLOs)			
Grade-IX	**Grade-X**	**Grade-XI**	**Grade-XII**
			[SLO:M-12-A-37]: Find the maximum and the minimum values of a function to solve real-life problems. **[SLO:M-12-A-38]:** Apply the concept of derivatives to solve real-life problems (such as transportation devices, rate of spread of a disease, rate of improvement of performance in psychology, radar guns, economics, data science and artificial intelligence). **Vector Valued Function** **[SLO:M-12-B -39]:** Explain the vector valued function, its uses, and differentiate scalar and vector valued functions. **[SLO:M-12-B -40]:** Construct a vector valued function, and identify its domain and range. **[SLO:M-12-B-41]:** Explain and find derivative of a vector function of a single variable. **[SLO:M-12-B -42]:** Apply vector differentiation to calculate velocity and acceleration of a vector valued function. **[SLO:M-12 -B -43]:** Apply concepts of vector valued functions to solve real-life problems.

Student Learning Outcomes (SLOs)			
Grade-IX	**Grade-X**	**Grade-XI**	**Grade-XII**
			Integration **[SLO:M-12-A-44]:** Define integration, integrand, variable of integration, integral/ antiderivative and constant of integration. **[SLO:M-12-A-45]:** Find the general antiderivative/integral of a given function. **[SLO:M-12-A-46]:** State the power rule for integrals with examples. **[SLO:M-12-A-47]:** Define indefinite integrals with examples; state and apply the properties of indefinite integrals. **[SLO:M-12-A-48]:** Explain the techniques of integration: • Integration by formulae • Integration by substitution • Integration by trigonometric substitution • Integration by parts • Integration by partial fractions **[SLO:M-12-A-49]:** Describe definite integral and limits of integration with examples. **[SLO:M-12-A-50]:** State and apply fundamental theorem of calculus to evaluate the definite integrals. **[SLO:M-12-A-51]:** State and apply the properties of definite integrals.

Student Learning Outcomes (SLOs)			
Grade-IX	**Grade-X**	**Grade-XI**	**Grade-XII**
			[SLO:M-12-A-52]: Describe the relationship between the definite integral and net area. **[SLO:M-12-A-53]:** Find the area of a region bounded by a curve and lines parallel to axes, between a curve and a line, or between two curves. **[SLO:M-12-A-54]:** Find volume of a solid of revolution about one of the axes. **[SLO:M-12-A-55]:** Apply concepts of integration to solve real-life problems (such as volume of a container, work done, growth rate of a population, drug dosage required by integrating the concentration). **[SLO:M-12-A-56]:** Explain and find the integration of vector valued functions of a single variable.
Factorization **[SLO:M-09-A-15]:** Identify common factors, trinomial factoring, pictorially and symbolically. **[SLO:M-09-A-16]:** Factorizing quadratic and cubic algebraic expressions: • $ax^2 + bx + c$ • $x^4 + px^2 + q$ • $a^4 + a^2 b^2 + b^4$ • $(ax^2 + bx + c)(ax^2 + bx + d)$ • $(x + a)(x + b)(x + c)$	**Algebraic Fractions** **[SLO:M-10-A-26]:** Describe polynomials, rational and irrational expressions with examples. **[SLO:M-10-A-27]:** Factorize and simplify rational expressions. **[SLO:M-10-A-28]:** Demonstrate manipulation of algebraic fractions. **[SLO:M-10-A-29]:** Perform operations on rational expressions (limited to numerators	**Sequences and Series** **[SLO:M-11-A-26]:** Define sequence, series and their types **[SLO:M-11-A-27]:** Solve problems by analysing arithmetic sequences, arithmetic mean(s) and series up to n terms. **[SLO:M-11-A-28]:** Solve problems by analysing geometric sequences, geometric mean(s) and series up to n and infinite terms.	

Student Learning Outcomes (SLOs)			
Grade-IX	**Grade-X**	**Grade-XI**	**Grade-XII**
• $a^3 + 3a^2b + 3ab^2 + b^3$ • $a^3 - 3a^2b + 3ab^2 - b^3$ • $a^3 \pm b^3$ **[SLO:M-09-A-17]:** Find Highest Common Factor (HCF) and Least Common Multiple (LCM) of algebraic expressions and to know the relationship of LCM and HCF. **[SLO:M-09-A-18]:** Find square root of the algebraic expression by factorization and division methods. **[SLO:M-09-A-19]:** Apply the concepts of factorization of quadratic and cubic algebraic expressions to real-life problems (such as engineering, physics, and finance).	and denominators that are monomials, binomials, or trinomials). **[SLO:M-10-A-30]:** Apply the concept of rational expressions (limited to numerators and denominators that are monomials, binomials, or trinomials) to solve real life problems (such as amount and rate of work). **[SLO:M-10-A-31]:** Recognise the surds and perform their rationalisation.	**[SLO:M-11-A-29]:** Solve problems by analysing harmonic sequences, mean(s) and series up to n terms. **[SLO:M-11-A-30]:** Explain relations among arithmetic geometric and harmonic means. **[SLO:M-11-A-31]:** Find sum of: • the first n natural numbers ($\sum n$). • the squares of the first n natural numbers ($\sum n^2$). • the cubes of the first natural numbers ($\sum n^3$). **[SLO:M-11-A-32]:** Apply concepts from sequence and series to solve real-life problems (such as simple interest on loan, leasing of vehicles, investment, depreciation, Investment planning on compound interest, projectile motion, gaming strategy, health care management, web page design, traffic modelling).	
Linear Equation and Inequalities in one/two variable **[SLO:M-09-A-20]:** Solve linear equations and inequalities with rational coefficients and represent the solution on a real line. **[SLO:M-09-A-21]:** Solve two linear inequalities with two unknowns simultaneously.	**Linear Inequalities in two variables** **[SLO:M-10-A-32]:** Solve two linear inequalities with two unknowns simultaneously. **[SLO:M-10-A-33]:** Interpret and Identify regions in plane bounded by two linear inequalities in two unknowns.		

Student Learning Outcomes (SLOs)			
Grade-IX	**Grade-X**	**Grade-XI**	**Grade-XII**
	Quadratic Equations **[SLO:M-10-A-34]:** Define and write quadratic equation in standard form. **[SLO:M-10-A-35]:** Solve quadratic equations by using the methods of factorization, completing squares, and quadratic formula. **[SLO:M-10-A-36]:** Establish relationship between roots and coefficients of quadratic equations. **[SLO:M-10-A-37]:** Form a quadratic equation when roots are given. **[SLO:M-10-A-38]:** Find discriminant of a given quadratic equation and identify the nature of its roots. **[SLO:M-10-A-39]:** Solve a pair of linear and quadratic equations simultaneously. **[SLO:M-10-A-40]:** Solve equations involving fractional exponent that can be reduced to quadratic equations e.g $(x^{\frac{2}{m}} - x^{\frac{1}{m}} - 12 = 0)$ **[SLO:M-10-A-41]:** Solve real-life situations by formulating a quadratic equation. (such as projectile motion and distance equation) **[SLO:M-10-A-42]:** Solve quadratic inequalities in one unknown.		

Student Learning Outcomes (SLOs)			
Grade-IX	**Grade-X**	**Grade-XI**	**Grade-XII**
	[SLO:M-10-A-43]: Apply the concept of quadratic equations and quadratic inequalities to solve real life problems. **[SLO:M-10-A-44]:** Sketch and differentiate graphs of the Linear and non-linear (quadratic and cubic) functions **[SLO:M-10-A-45]:** Solve a system of one linear and one quadratic equation graphically and interpret the solution. **[SLO:M-10-A-46]:** Apply concepts of sketching and interpreting graph to solve real-life problems (such as in tax payment, income and salary problems, cost and profit analysis).		
		Mathematical Induction **[SLO:M-11-A-33]:** Describe a mathematical argument, identify the base case, induction of hypothesis and a precise conclusion. **[SLO:M-11-A-34]:** Apply the principle of mathematical induction to prove statements, identities, divisibility of numbers and summation formulae. **[SLO:M-11-A-35]:** Evaluate and justify conclusions, communicating a position clearly in an appropriate mathematical form in daily life. **Binomial Theorem** **[SLO:M-11-A-36]:** State and apply the binomial theorem to	

Student Learning Outcomes (SLOs)			
Grade-IX	**Grade-X**	**Grade-XI**	**Grade-XII**
		expand expressions of the form $(a+b)^n$ where n is a positive integer. **[SLO:M-11-A-37]:** Calculate binomial coefficients using Pascal's triangle. **[SLO:M-11-A-38]:** Expand using the binomial theorem, and use appropriate techniques to simplify the expression. **[SLO:M-11-A-39]:** State and apply the binomial theorem to expand expression of the form $(1+x)^n$, $\|x\| < 1$, where x is negative or fraction. **[SLO:M-11-A-40]:** Find an approximate value using binomial theorem. **[SLO:M-11-A-41]:** Use binomial theorem to find the remainder when a number to some large exponent is divided by a number. **[SLO:M-11-A-42]:** Use binomial theorem to find the last digit of a number, test the divisibility by a number and compare two large numbers. **[SLO:M-11-A-43]:** Apply concepts of mathematical induction and binomial theorem to solve rea- life problems such as (puzzles, domino effects, Pascal's triangle, economic forecasting).	

Student Learning Outcomes (SLOs)			
Grade-IX	**Grade-X**	**Grade-XI**	**Grade-XII**
		Division of polynomial **[SLO:M-11-A-44]:** Divide a polynomial of degree up to 4 by a linear and quadratic polynomial to identify quotient and remainder. **[SLO:M-11-A-45]:** Demonstrate and apply remainder theorem. **[SLO:M-11-A-46]:** Analyse and apply factor theorem to factorise a cubic polynomial **[SLO:M-11-A-47]:** Express an algebraic fraction into partial fraction involving all the four cases: • when the factors in the denominator are linear and distinct • when the factors in the denominator are linear and repeated linear • when the factors in the denominator are irreducible quadratic and distinct • when the factors in the denominator are irreducible quadratic and quadratic repeated **[SLO:M-11-A-48]:** Apply concepts of remainder and factor theorem to solve real-life problems (such as polynomial regression, signal processing, and coding theory).	
			Mechanics Kinematics of motion in a straight line **[SLO:M-12-A-57]:** Define vector differentiation and vector integration with examples.

Student Learning Outcomes (SLOs)			
Grade-IX	**Grade-X**	**Grade-XI**	**Grade-XII**
			[SLO:M-12-A-58]: Use differentiation and integration with respect to time to solve simple problems concerning displacement, velocity and acceleration.
			Differential Equations **[SLO:M-12-A-59]:** Define ordinary and partial differential equations. **[SLO:M-12-A-60]:** Explain order and degree of ordinary differential equations with examples. **[SLO:M-12-A-61]:** Explain solution and types of solution of ordinary differential equations (ODEs). **[SLO:M-12-A-62]:** Explain initial and boundary conditions with examples. **[SLO:M-12-A-63]:** Form ordinary differential equations by elimination of arbitrary constant(s). **[SLO:M-12-A-64]:** Describe and apply techniques for solution of ordinary differential equations: • Separable variable method • Equations reducible to separable form • Homogeneous equations **[SLO:M-12-A-65]:** Apply concepts of first order differential equations to solve real-life problems (such as growth and decay,

Student Learning Outcomes (SLOs)			
Grade-IX	**Grade-X**	**Grade-XI**	**Grade-XII**
			Cooling/Warming law, flow of electricity, series circuits, economics, finance and machine learning).
			Numerical Solution of Nonlinear Equations **[SLO:M-12-A-66]:** Analyse roots/zeros of nonlinear equations $(f(x) = 0)$ graphically and by using intermediate value theorem (IVT). **[SLO:M-12-A-67]:** Find real roots of a nonlinear equation in one variable by: • Bisection method • Regula-falsi method • Newton-Raphson method **[SLO:M-12-A-68]:** Apply methods of nonlinear equations to solve real-life problems (such as chemical reactions, regulation of heart beats, electronic circuits, and cryptography).

Domain B: Geometry

Geometry is the most practical branch of mathematics that deals with shapes and sizes of figures and their properties. The basic elements of geometry are points, lines, angles, surfaces and solids. Develops reasoning and problem-solving skills by applying properties of lines, triangles, quadrilaterals, and circles. Length, perimeter, area, circumference, surface area, and volume to solve real-world problems.

Standards:

- Apply characteristics and properties of angles, triangles, parallelograms and circles to develop arguments about their geometric relationships.
- Solve problems involving coordinate geometry, plane analytical geometry and vectors.
- Recognize trigonometric identities, analyze conic sections, draw and interpret graphs of functions.

Benchmarks (Grade IX – X)	Benchmarks (Grade XI – XII)
Benchmark I: Students will be able to use and interpret cartesian coordinates in two dimensions and solve problems involving coordinate geometry. **Benchmark II:** Students will be able to Identify vectors in plane and apply vector addition, dot/ cross product, scalar product. **Benchmark III:** Students will be able to: • Find volume and surface area of composite solids. • Solve problems using the relationship between areas of similar figures and volume of different solids. **Benchmark IV:** Students will be able to apply characteristics and properties of angles, triangles, parallelograms and circles to develop arguments about their geometric relationships. **Benchmark V:** Students will be able to: • Use trigonometric identities to verify relationships between trigonometric ratios. • Apply appropriate laws and formulae of trigonometry to solve the triangles and relevant problems. **Benchmark VI:** Students will be able to calculate unknown angles and solve problems by using the properties of circles.	**Benchmark I:** Students will be able to interpret and solve plane analytical geometry problem situations. **Benchmark II:** Students will be able to Identify vectors in space and apply vector addition, dot/ cross product and scalar product. **Benchmark III:** Students will be able to Identify and analyse conic sections (circle, parabola, ellipse and hyperbola) and solve related problems. **Benchmark IV:** Students will be able to apply trigonometric identities and formulas to solve relevant situations and draw graphs of trigonometric and inverse trigonometric functions.

Student Learning Outcomes (SLOs)			
Grade-IX	**Grade-X**	**Grade-XI**	**Grade-XII**
Co-ordinate Geometry [SLO:M-09-B-01]: Derive distance formula by locating the position of two points in a co-ordinate plane and apply the formula to solve problems.	**Co-ordinate Geometry [SLO:M-10-B-01]:** Find the gradient of parallel and perpendicular lines.		**Analytical Geometry Concurrency of Straight lines [SLO:M-12-B -01]:** Explain and use the condition of concurrency of three straight lines.

Student Learning Outcomes (SLOs)			
Grade-IX	**Grade-X**	**Grade-XI**	**Grade-XII**
[SLO:M-09-B-02]: Derive the midpoint formula and use it to calculate the midpoint of a line segment. **[SLO:M-09-B-03]:** Explain and use the formula to find the gradient of a straight line when co-ordinates of two points are given. **[SLO:M-09-B-04]:** Find the equation of straight line in the form, $y = mx + b$ **[SLO:M-09-B-05]:** Apply distance and midpoint formulas to solve real life problems such as physical measurements or distance between locations.	**[SLO:M-10-B-02]:** Drive equation of a straight line in slope-intercept form, point-slope form, two points form, intercepts form, symmetric form, and normal form. **[SLO:M-10-B-03]:** Show that a linear equation in two variables represents a straight line and reduce the general form of the equation of a straight line to the other standard forms. **[SLO:M-10-B-04]:** Apply concepts form co-ordinate geometry to real world problems (such as aviation and navigation, landscaping, map reading, longitude and latitude). **Angle between Lines** **[SLO:M-10-B-05]:** Find the angle between two coplanar intersecting straight lines. **[SLO:M-10-B-06]:** Find the equation of the family lines passing through the point of intersection of two given lines. **[SLO:M-10-B-07]:** Calculate angles of the triangle when the slopes of the sides are given.		**[SLO:M-12-B -02]:** Find the equation of median, altitude and right bisector of a triangle. **[SLO:M-12-B -03]:** Show that: • three right bisectors • three medians, and • three altitudes of a triangle are concurrent. **[SLO:M-12-B -04]:** Find the area of a triangular region whose vertices are given. **[SLO:M-12-B -05]:** Explain and recognise homogeneous linear and quadratic equations in two variables. **[SLO:M-12-B -06]:** Show that the 2nd degree homogeneous equation in two variables represents a pair of straight lines through the origin, and find an acute angle between them. **[SLO:M-12 -B -07]:** Apply concepts of analytical geometry to solve real-life problems (such as distance between planets and satellites, space science and engineering).
	Vectors in Plane **[SLO:M-10-B-08]:** Explain rectangular coordinate system in a plane. **[SLO:M-10-B-09]:** Represent vectors as directed line segment.	**Vectors in Space** **[SLO:M-11-B-01]:** Recognize rectangular coordinate system in space. **[SLO:M-11-B-02]:** Explain unit vectors and components of a vector *u, i, j* and *k*.	

Student Learning Outcomes (SLOs)			
Grade-IX	**Grade-X**	**Grade-XI**	**Grade-XII**
	[SLO:M-10-B-10]: Express a vector in terms of two non-zero and non-parallel coplanar vectors. **[SLO:M-10-B-11]:** Express a vector in terms of position vector. **[SLO:M-10-B-12]:** Express translation by a vector. **[SLO:M-10-B-13]:** Find the magnitude of a vector. **[SLO:M-10-B-14]:** Add and subtract vectors. **[SLO:M-10-B-15]:** Multiply a vector by a scalar. **[SLO:M-10-B-16]:** Solve geometrical problems involving the use of vectors.	**[SLO:M-11-B-03]:** Find the magnitude of a vector. **[SLO:M-11-B-04]:** Apply all fundamental mathematical operations for vectors in plane space which in the plane, have already been discussed. **[SLO:M-11-B-05]:** Demonstrate and prove properties of Vector Addition. • Commutative law for vector addition. • Associative law for vector addition. • 0 as the identity for vector addition. • -A as the inverse for A. **[SLO:M-11-B-06]:** Explain dot or scalar product of two vectors and give its geometrical interpretation. **[SLO:M-11-B-07]:** Prove that; • $i \cdot i = j \cdot j = k \cdot k = 1$ • $i \cdot j = j \cdot k = k \cdot i = 0$ **[SLO:M-11-B-08]:** Express dot product in terms of components. **[SLO:M-11-B-09]**: Find the condition for orthogonality of two vectors. **[SLO:M-11-B-10]:** Use dot product to find the angle between two vectors. **[SLO:M-11-B-11]:** Find the projection of a vector along another vector.	

Student Learning Outcomes (SLOs)			
Grade-IX	**Grade-X**	**Grade-XI**	**Grade-XII**
		[SLO:M-11-B-12]: Solve real life problem base on dot product. **[SLO:M-11-B-13]:** Explain the cross or vector product of two vectors and give its geometrical interpretation. **[SLO:M-11-B-14]:** Prove that; • $i \times i = j \times j = k \times k = 0$ • $i \times j = -j \times i = k$ • $j \times k = -k \times j = i$ • $k \times i = -i \times k = j$ **[SLO:M-11-B-15]:** Apply a cross product to find the angle between two vectors. **[SLO:M-11-B-16]:** Solve daily life problems based on cross product. **Scalar Triple Product** **[SLO:M-11-B-17]:** Describe scalar triple product of vectors. **[SLO:M-11-B-18]:** Express scalar triple product of vectors in terms of components (determinant form). **[SLO:M-11-B-19]:** Prove that: • $i \cdot (j \times k) = j \cdot (k \times i) = k \cdot (i \times j) = 1$ • $i \cdot (k \times j) = j \cdot (i \times k) = k \cdot (j \times i) = -1$ **[SLO:M-11-B-20]:** Prove that dot and cross are inter-changeable in scalar triple product. **[SLO:M-11-B-21]:** Find the volume of	

Student Learning Outcomes (SLOs)			
Grade-IX	**Grade-X**	**Grade-XI**	**Grade-XII**
		• a parallelepiped, • tetrahedron, determined by three given vectors. **[SLO:M-11-B-22]:** Define coplanar vectors and find the condition for planarity of three vectors. **[SLO:M-11-B-23]:** Apply concepts of vectors in space to solve real-life problems such as (graphing complex 3D motion, vector operations in engineering and computer graphics, practical proficiency for work, flux, and circulation).	
Similar figures **[SLO:M-09-B-06]:** Identify and examine similarity of polygons, and the relationship between area and volume of similar figures. **[SLO:M-09-B-07]:** Solve problems using the relationship between areas of similar figures and volume of different solids. **Geometrical Properties of Regular Polygons, Triangles and Parallelograms** **[SLO:M-09-B-08]:** Solve real-life problems that involve the properties of regular polygons, triangles and parallelograms (such as building architectural structure, fencing, tiling, painting, carpeting a room).			

Student Learning Outcomes (SLOs)			
Grade-IX	**Grade-X**	**Grade-XI**	**Grade-XII**
Loci **[SLO:M-09-B-09]:** Solve real-life problems using the following loci and the method of intersecting loci for sets of points in two dimensions which are: • at a given distance from a given point, at a given distance from a given straight line. • equidistant from two given points, equidistant from two given intersecting straight lines.			
Trigonometry **[SLO:M-09-B-10]:** Identify angles in standard position, expressed in degrees and radians. **[SLO:M-09-B-11]:** Apply Pythagoras' theorem, and sine, cosine and tangent ratios to find a side and acute angles of a right-angled triangle respectively. **[SLO:M-09-B-12]:** Solve real-life trigonometric problems in two dimension involving angles of elevation and depression. **[SLO:M-09-B-13]:** Prove the trigonometric identities and apply them to show different trigonometric relations. **[SLO:M-09-B-14]:** Solve real-life problems involving trigonometric identities.	**Application of Trignometry** **[SLO:M-10-B-17]:** Extend sine and cosine functions to angles between 90° and 180°. **[SLO:M-10-B-18]:** Solve problems using the laws of sine, cosine and the area formulas for any triangle. **[SLO:M-10-B-19]:** Apply concepts of trigonometry to solve real-life problems (such as video games, flight engineering, navigation, sound waves).	**Fundamental Law of Trigonometry** **[SLO:M-11-B -24]:** Explain distance formula between two points in 2-D, and then establish fundamental law of trigonometry. **[SLO:M-11-B-25]:** Apply fundamental law and its deductions to derive trigonometric ratios of allied angles, double angle, half angle and triple angle identities. **[SLO:M-11-B-26]:** Express the product (of sines and cosines) as sums or differences (of sines and cosines) and vice versa. **Trigonometric Functions** **[SLO:M-11-B -27]:** Find the domain and range of the trigonometric functions. **[SLO: M-11-B -28]:** Discuss even, odd functions, the periodicity and amplitude of trigonometric functions.	

Student Learning Outcomes (SLOs)			
Grade-IX	**Grade-X**	**Grade-XI**	**Grade-XII**
Bearing **[SLO:M-09-B-15]:** Interpret and use bearings. **[SLO:M-09-B-16]:** Solve problems involving bearing.		**[SLO: M-11-B -29]:** Find the maximum and minimum value of a given function of the type: • $a + b\ sin\theta$, • $a + b\ cos\theta$, • $a + bcos(c\theta + d)$ the reciprocals of above, where a, b, c and d are real numbers. **Graphs of Trigonometric Functions** **[SLO:M-11-B-30]:** Graph and analyse the trigonometric functions sine, cosine, and tangent to solve problems. **[SLO:M-1l-B -31]:** Explain the properties of graphs of $sin\theta$, $cos\theta$, and $tan\theta$. **[SLO:M-11-B -32]:** Apply the concepts of trigonometric functions, identities, graphs, periodicity, even odd functions, extreme values to solve real-life problems, (such as distance, elevation, and direction of tall structures, navigation and mapping, lengths of irregular shapes, graphs to visualize and predict patterns in data, frequency and periodic length of Ferris wheel, the ideal angle for solar panel placement).	

Student Learning Outcomes (SLOs)			
Grade-IX	**Grade-X**	**Grade-XI**	**Grade-XII**
	Chords and Arcs of a Circle **[SLO:M-10-B-20]:** Solve problems by using the property of a circle: One and only one circle can pass through three non collinear points. **[SLO:M-10-B-21]:** Solve problems by using the property of circle: A straight line, drawn from the centre of a circle to bisect a chord (which is not a diameter) is perpendicular to the chord. **[SLO:M-10-B-22]:** Solve problems by using the property of a circle: Perpendicular from the centre of a circle on a chord bisects it. **[SLO:M-10-B-23]:** Solve problems by using the property of circle: If two chords of a circle are congruent then they will be equidistant from the centre. **[SLO:M-10-B-24]:** Solve problems by using the property of a circle: Two chords of a circle which are equidistant from the centre are congruent. **[SLO:M-10-B-25]:** Solve problems by using the property of circle: If two arcs of a circle (or of congruent circles) are congruent then the corresponding chords are equal.		**Conics** **[SLO:M-12-B -08]:** Demonstrate conics and members of its family i.e. circle, parabola, ellipse and hyperbola. **[SLO:M-12-B -09]:** Derive and apply equation of a circle in standard and general form. **[SLO:M-12-B -10]:** Find the equation of a circle passing through: three non collinear points, two points and having its centre on a given line, two points and equation of tangent at one of these points is known, two points and touching a given line. **[SLO:M-12-B -11]:** Find the condition when: • a line intersects the circle • a line touches the circle. **[SLO:M-12-B -12]**: Find the equation of a tangent and normal to a circle in slope form at a point. [**SLO:M-12-B -13]:** Find the length of tangent to a circle from a given external point. **[SLO:M-12-B -14]:** Derive and apply the standard equation of a parabola. **[SLO:M-12-B -15]:** Sketch the graphs of parabola and find its elements.

Student Learning Outcomes (SLOs)			
Grade-IX	**Grade-X**	**Grade-XI**	**Grade-XII**
	[SLO:M-10-B-26]: Solve problems by using the property of circle: If two chords of a circle (or of congruent circles) are equal, then their corresponding arcs (minor, major or semi-circular) are congruent. **[SLO:M-10-B-27]:** Solve problems by using the property of circle: Equal chords of a circle (or of congruent circles) subtend equal angles at the centre (at the corresponding centres). **[SLO:M-10-B-28]:** Solve problems by using the property of circle: If the angles subtended by two chords of a circle (or congruent circles) at the centre (corresponding centres) are equal, the chords are equal. **[SLO:M-10-B-29]:** Apply concepts of chords and arcs of a circle to solve real-life problems (such as decorative features, rainbow, bridges, roller coaster track). **Tangent and Angles of a Circle** **[SLO:M-10-B-30]:** Solve problems by using the property of circle: If a line is drawn perpendicular to a radial segment of a circle at its outer end point, it is tangent to the circle at that point. **[SLO:M-10-B-31]:** Solve problems by using the property of a circle: The tangent to a circle		**[SLO:M-12-B -16]:** Find the equation of a parabola with the following given elements: focus and vertex, focus and directrix, vertex and directrix. **[SLO:M-12-B-17]:** Find the condition when a line is tangent to a parabola at a point. **[SLO:M-12-B-18]:** Find the equation of a tangent and a normal to a parabola at a point. **[SLO:M-12-B-19]:** Derive and apply the standard form of equation of an ellipse and identify its elements. **[SLO:M-12-B-20]:** Convert a given equation to the standard form of equation of an ellipse, find its elements and draw the graph. **[SLO:M-12-B -21]:** Find the condition of tangency of an ellipse and points of intersection of a line and the ellipse. **[SLO:M-12-B -22]:** Find the equation of a tangent and a normal to an ellipse at a point. **[SLO:M-12-B -23]:** Derive and apply standard form of equation of a hyperbola and identify its elements. **[SLO:M-12-B -24]:** Find the equation of a hyperbola with the following given elements: transverse and

Student Learning Outcomes (SLOs)			
Grade-IX	**Grade-X**	**Grade-XI**	**Grade-XII**
	and the radial segment joining the point of contact and the centre are perpendicular to each other. **[SLO:M-10-B-32]:** Solve problems by using the property of circle: The two tangents drawn to a circle from a point outside it, are equal in length. **[SLO:M-10-B-33]:** Solve problems by using the property of a circle: If two circles touch externally or internally, the distance between their centres is respectively equal to the sum or difference of their radii. **[SLO:M-10-B-34]:** Solve problems by using the property of circle: The measure of a central angle of a minor arc of a circle is double that of the angle subtended by the corresponding major arc. **[SLO:M-10-B-35]:** Solve problems by using the property of a circle: Any two angles in the same segment of a circle are equal. **[SLO:M-10-B-36]:** Solve problems by using the property of circle: The angle in a semi-circle is a right angle, in a segment greater than a semi-circle is less than a right angle, in a segment less than a semi-circle is greater than a right angle.		conjugate axes with centre at origin, two points, eccentricity, latera recta and transverse axes, foci, eccentricity and centre, centre and directrix. **[SLO:M-12-B-25]:** Find the condition of tangency of a hyperbola and points of intersection of a line and the hyperbola. **[SLO:M-12-B-26]:** Find the equation of a tangent and a normal to a hyperbola at a point. **[SLO:M-12 -B-27]:** Apply concepts of conics to solve real-life problems (such as suspension and reflection problems related to parabola, Satellite system, elliptic movement of electrons in the at around the nucleus, radio system use as hyperbolic functions flashlights, conics in architecture).

Student Learning Outcomes (SLOs)			
Grade-IX	**Grade-X**	**Grade-XI**	**Grade-XII**
	[SLO:M-10-B-37]: Solve problems by using the property of circle: The opposite angles of any quadrilateral inscribed in a circle are supplementary. **[SLO:M-10-B-38]:** Apply concepts of tangents and angles of a circle to solve real-life problems (such as architecture, monuments, pyramids).		
			Inverse Trigonometric Functions **[SLO:M-12-B-28]:** Find domains and ranges of principal trigonometric functions, inverse trigonometric functions. **[SLO:M-12-B-29]:** Draw the graphs of the inverse trigonometric functions of cosine, sine, tangent, secant, cosecant and cotangent within the domain from -2π to 2π . **[SLO: M-12-B-30]:** State, prove and apply the addition and subtraction formulae of inverse trigonometric functions. **[SLO: M-12-B-31]:** Solve trigonometric equations of the type $\sin\theta = k, \cos\theta = k \text{ and } tan\theta = k,$ where $k \in R,$ using periodic, even, odd and translation properties. **[SLO: M-12-B-32]:** Solve graphically the trigonometric equations of the type: $\sin\theta = \frac{\theta}{2}$, $\cos\theta = \theta$, $\tan\theta = 2\theta$, where $-\pi < \theta < \pi$

Student Learning Outcomes (SLOs)			
Grade-IX	**Grade-X**	**Grade-XI**	**Grade-XII**
			[SLO: M-12-B -33]: Use the periods of trigonometric functions to find the general solution of the trigonometric equations. **[SLO: M-12 -B -34]:** Apply concepts of inverse trigonometric functions to solve real-life problems (such as mechanical engineering, architecture to find the height of the building, angle of elevation and depression, identifying the angle of bridges to build scale models).
Construction of Triangle **[SLO:M-09-B-17]:** Construct a triangle having given two side and the included angle. **[SLO:M-09-B-18]:** Construct a triangle having given one side and two of the angles. **[SLO:M-09-B-19]:** Construct a triangle having given two of its sides and the angle opposite to one of them (with all the three possibilities). **[SLO:M-09-B-20]:** Draw angle bisectors, perpendicular bisectors, medians altitudes of a given triangle and verify their concurrency.	**Practical Geometry of Circles** **[SLO:M-10-B-39]:** Locate the centre of a given circle. **[SLO:M-10-B-40]:** Draw a circle passing through three given non-collinear points. **[SLO:M-10-B-41]:** Complete the circle: • by finding the centre, • without finding the centre, when a part of its circumference is given. **Tangent to the Circle** **[SLO:M-10-B-42]:** Draw a tangent to a given arc, without using the centre, through a given point P when P is • the middle point of the arc, • at the end of the arc, • outside the arc.		

Student Learning Outcomes (SLOs)			
Grade-IX	**Grade-X**	**Grade-XI**	**Grade-XII**
	[SLO:M-10-B-43]: Draw a tangent to a given circle from a point P when P lies on the circumference and outside the circle. **[SLO:M-10-B-44]:** Draw two tangents to a circle meeting each other at a given angle. **[SLO:M-10-B-45]:** Apply concepts of practical geometry of a circle to solve real-life problems (such as athletic tracks, recreational parks, ferry wheel, mechanical machines)		

Domain C: Information Handling

Mathematics is the study of order, relation and pattern. From its origins in counting and measuring it has evolved in highly sophisticated and elegant ways to become the language now used to describe much of the modern world. Statistics is concerned with collecting, analysing, modelling and interpreting data in order to investigate and understand real-world phenomena and solve problems in context. Together, mathematics and statistics provide a framework for thinking and a means of communication that is powerful, logical, concise and precise. Statistics is used to describe and analyse phenomena involving uncertainty and variation. For these reasons this domain provides a foundation for further studies in disciplines in which mathematics and statistics have important roles. It is also advantageous for further studies in the health and social sciences. In summary, the curriculum is designed for students whose future pathways may involve mathematics and statistics and their applications in a range of disciplines at the tertiary level. In the 2006 National curriculum, the percentage of statistical concepts as compared to O-level and A-level is not appropriate therefore concepts of normal distribution are added to the SLOs of Grade XII and Permutation/Combination and laws of probability are shifted to grade XI.

Standards:

Collect, organize, display and interpret data/information.

Benchmarks (Grade IX – X)	Benchmarks (Grade XI – XII)
Benchmark I: Students will be able to find measures of central tendency and dispersion to draw conclusion, construct and interpret cumulative frequency curve, measure correlation using scatter diagram. **Benchmark II:** Students will be able to explain the concepts of permutations and combinations **Benchmark III:** Students will be able to predict the outcomes of single and combined events using diagrams.	**Benchmark I:** Students will be able to solve problems involving permutations and combinations **Benchmark II:** Students will be able to find probability and recognise probabilities of compound events.

Student Learning Outcomes (SLOs)			
Grade-IX	**Grade-X**	**Grade-XI**	**Grade-XII**
Frequency Distribution: [SLO:M-09-C-01]: Construct a grouped frequency table, histogram (with unequal class intervals) and frequency polygon. **Measure of Central Tendency: [SLO:M-09-C-02]:** Calculate the mean modal class and median of a grouped frequency distribution. **[SLO:M-09-C-03]:** Solve real-life situations involving mean, weighted mean, median,	**Cumulative Frequency Distribution and measures of dispersion: [SLO:M-10-C-01]:** Construct cumulative frequency table, cumulative frequency polygon or Ogive. **[SLO:M-10-C-02]:** Interpret the median, quartiles, deciles, percentiles, and inter quartile range from cumulative frequency curve. **[SLO:M-10-C-03]:** Calculate the range, mean deviation, standard		

Student Learning Outcomes (SLOs)			
Grade-IX	**Grade-X**	**Grade-XI**	**Grade-XII**
and mode for given data (such as allocation of funds in different projects, forecasting future demographics, marketing, forecasting government budgets).	deviation and variance for grouped data. **[SLO:M-10-C-04]:** Use the mean and standard deviation to compare two sets of data. **[SLO:M-10-C-05]:** Solve real-life problems involving variance, and standard deviation for grouped data (e.g. checking variability in forecasting, manufacturing, finance, economics etc.).		
Probability: **[SLO:M-09-C -04]:** Calculate the probability of a single event (occurring/not occurring). **[SLO:M-09-C -05]:** Solve real-life problems involving probability. **Relative and expected frequencies:** **[SLO:M-09-C -06]:** Calculate relative frequency as an estimate of probability. **[SLO:M-09-C -07]:** Calculate expected frequencies. **[SLO:M-09-C -08]:** Solve real-life problems involving relative and expected frequencies.	**Probability of Combined Events:** **[SLO:M-10-C-06]:** Explain permutation and combination **[SLO:M-10-C-07]:** Calculate the probability of combined events using, where appropriate: sample space diagrams, possibility diagram, tree diagrams, Venn diagrams.	**Permutation and Combination:** **[SLO:M-11-C-01]:** Explain and solve problems that involve the fundamental counting principle. **[SLO:M-11-C-02]:** Explain and solve problems that involve permutations. **[SLO:M-11-C-03]:** Explain and Solve problems that involve combinations. **[SLO:M-11-C -04]:** Apply the concepts of permutation and combination to real-life problems such as (cryptography, calculating the number of possible DNA sequences or protein structures, choosing different sets of songs for certain occasions). **Laws of Probability** **[SLO:M-11-C-05]:** Apply laws of probability (addition/ multiplication) to solve problems involving	

Student Learning Outcomes (SLOs)			
Grade-IX	**Grade-X**	**Grade-XI**	**Grade-XII**
		mutually exclusive events (such as left and right-hand turns, tossing a coin, even and odd numbers on a die).	

TEACHING AND LEARNING MATHEMATICS

The purpose of these guidelines for effective mathematics teaching practices and beliefs that can lead to greater student learning along with examples of activities and assessments that can help achieve this. The primary focus of this teacher guide is to equip teachers with the knowledge and tools needed to shift from "unproductive" mathematics classrooms where students sit in rows, silently watching the teacher solve questions while copying notes from the board and doing a series of repetitive practice problems, to "productive" student-centered classrooms where the teacher acts as a facilitator and students sit in small groups, engaging in productive mathematical discussions. Active approaches of teaching and learning not only allow students to see the true nature of mathematics where reason and thought are critical, but also help students increase their understanding of mathematical concepts. Shifting from Unproductive to Productive Mathematics Classrooms Our aim for the Mathematics Sindh Curriculum 2024 is to develop five learning strands in students that constitute the learning of mathematics:

1. **Conceptual understanding:** comprehending and relating mathematical concepts, operations, and relationships.
2. **Procedural fluency:** effectively and efficiently utilizing procedures to solve problems.
3. **Strategic competence:** formulating, expressing and solving mathematical problems.
4. **Adaptive reasoning:** thinking logically and justifying one's reasoning.
5. **Productive disposition:** viewing Mathematics as meaningful, worthwhile, and achievable through effort and hard work, and having a positive self-image as a competent learner and doer of mathematics.

In order to achieve this high level of mathematical learning, we need to provide students with rich opportunities and experiences within the mathematics classrooms. This includes:

- Involving students in demanding activities that require active comprehension and foster meaningful learning.
- Linking new information with prior knowledge and informal reasoning, and addressing any misunderstandings.
- Promoting the understanding of concepts as well as procedures, so students can effectively categorize their knowledge, learn new information, and apply it to new situations.
- Fostering a social learning environment through discourse, activities, and interaction while working on meaningful problems.
- Providing timely and detailed feedback to students, allowing them to reflect and improve their work, thoughts, and understanding.
- Enhancing students' self-awareness as learners, thinkers, and problem-solvers and teaching them to monitor their learning and performance.

The role of the teacher is very crucial in shifting our mathematics classrooms from silent, teacher-led classrooms to active, student-led classrooms where the above experiences are taking place. It is critical for teachers to understand the importance of this change and believe in their abilities to help implement this change.

Currently, most of our students go through silent math classrooms that make them view mathematics as a difficult and boring subject. The lack of feedback from the teacher and other students, and the chase to get to the right answer, forces the students to see mathematics as a subject where there is no room for analysis, reason, and inquiry. On the contrary, mathematicians have argued with one another

over what is right or wrong, instead of accepting the ideas as presented to them. Coming to conclusions through reasoning and justifying one's work to others is what mathematicians engage in and doing so makes one realize that mathematics is not about a set of rules that one can memorize, but instead it is a subject that is open to interpretation, new ideas and thoughts. We need to work towards this idea and build classrooms that encourage students to act and think like mathematicians, and that give space for students to demonstrate their thinking.

The table below highlights the true role of a teacher and student in classrooms by summarizing the unproductive and productive beliefs regarding the teaching and learning of mathematics.

Beliefs about teaching and learning mathematics	
Unproductive beliefs	**Productive beliefs**
Mathematics learning should focus on practicing procedures and memorizing basic number combinations.	Mathematics learning should focus on developing understanding of concepts and procedures through problem solving, reasoning, and discourse.
Students need only to learn and use the same standard computational algorithms and the same prescribed methods to solve algebraic problems.	All students need to have a range of strategies and approaches from which to choose in solving problems, including, but not limited to, general methods, standard algorithms, and procedures.
Students can learn to apply mathematics only after they have mastered the basic skills.	Students can learn mathematics through exploring and solving contextual and mathematical problems.
The role of the teacher is to tell students exactly what definitions, formulas, and rules they should know and demonstrate how to use this information to solve mathematics problems.	The role of the teacher is to engage students in tasks that promote reasoning and problem solving and facilitate discourse that moves students toward shared understanding of mathematics.
The role of the student is to memorize information that is presented and then use it to solve routine problems on homework, quizzes, and tests.	The role of the student is to be actively involved in making sense of mathematics tasks by using varied strategies and representations, justifying solutions, making connections to prior knowledge or familiar contexts and experiences, and considering the reasoning of others.
An effective teacher makes the mathematics easy for students by guiding them step by step through problem solving to ensure that they are not frustrated or confused.	An effective teacher provides students with appropriate challenge, encourages perseverance in solving problems, and supports productive struggle in learning mathematics.

Taken from NCTM (2014)

Teaching Practices

To facilitate teachers to move towards this shift in mathematics teaching and learning, the table below highlights eight effective research-informed teaching practices:

Mathematics Teaching Practices
Establish mathematics goals to focus learning. Effective teaching of mathematics establishes clear goals for the mathematics that students are learning, situates goals within learning progressions, and uses the goals to guide instructional decisions.
Implement tasks that promote reasoning and problem solving. Effective teaching of mathematics engages students in solving and discussing tasks that promote mathematical reasoning and problem solving and allow multiple entry points and varied solution strategies.
Use and connect mathematical representations. Effective teaching of mathematics engages students in making connections among mathematical representations to deepen understanding of mathematics concepts and procedures and as tools for problem solving.
Facilitate meaningful mathematical discourse. Effective teaching of mathematics facilitates discourse among students to build shared understanding of mathematical ideas by analyzing and comparing student approaches and arguments.
Pose purposeful questions. Effective teaching of mathematics uses purposeful questions to assess and advance students' reasoning and sense making about important mathematical ideas and relationships.
Build procedural fluency from conceptual understanding. Effective teaching of mathematics builds fluency with procedures on a foundation of conceptual understanding so that students, over time, become skillful in using procedures flexibly as they solve contextual and mathematical problems.
Support productive struggle in learning mathematics. Effective teaching of mathematics consistently provides students, individually and collectively, with opportunities and supports to engage in productive struggle as they grapple with mathematical ideas and relationships.
Elicit and use evidence of student thinking. Effective teaching of mathematics uses evidence of student thinking to assess progress toward mathematical understanding and to adjust instruction continually in ways that support and extend learning.

Taken from NCTM (2014)

To help understand and demonstrate these teaching practices, the teachers can follow the below teaching cycle, which links the teaching practices to the Sindh Curriculum 2024 designed for Mathematics:

1. Establish goals

One of the key steps to planning a lesson is deciding on what you want the students to learn from that particular lesson. For this, it is important to know where the lesson sits in the overall curriculum and how it connects with the other units. The teachers should make themselves familiar with the Cross-cutting themes, standards, benchmarks and Student Learning Outcomes to help them establish their

specific lesson goals. To help teachers get started, some of the topics have been further broken down into smaller, more achievable goals in the knowledge, skills and perspectives section in the Curriculum guide. For e.g. in the functions unit, an intended procedural outcome is, "Identify examples and non-examples of functions," which accompanies the conceptual outcome of "Functions are single-valued mappings from the domain to the range." These lesson goals can be used as the foundation for the lesson where the launch of the lesson, main activities involving problem-solving tasks and discussions, and the wrap-up of the lesson are all designed to achieve the intended goal.

2. Select/design great tasks

Students should be engaged in solving challenging mathematical tasks that help them discover and connect with mathematical ideas, instead of questions that require students to memorize formulas and routinely apply standard algorithms.. The curriculum guide has examples of learning activities that are group-worthy and cognitively demanding. These tasks will push students to make connections between different representations and strategies, justify their work through reasoning, build on their previous knowledge, and engage in productive struggle. Good problem solving tasks are also "low floor, high ceiling", meaning that they are easily accessible for all kinds of learners as they allow multiple entry points, yet lead to rich mathematical ideas which help spur student curiosity and interest.

Teachers should also select tasks that will highlight at least one aspect of the nature of mathematics, including its connections with the other disciplines, as outlined in the Cross-cutting themes. They should provide students with the opportunity to reflect on their views of Nature of Mathematics within a unit, highlight any particular aspect that naturally comes up during the teaching activities, and then at the end of a unit, provide students the opportunity to reflect on and refine their views on the Nature of Mathematics. Teachers can take help from the sample learning activities presented in this guide that incorporate the nature of mathematics. It is important to realize that all fun-based activities or real-world connections might not be appropriate if the tasks are not leading to the learning of some important mathematical idea. The teachers should solve the selected tasks themselves to see the potential big ideas they would want to highlight that connect with their intended lesson goals. They should make predictions about the different ways students may solve and struggle. This will help them come up with questions they could pose during the class that will support group thinking and collaboration.

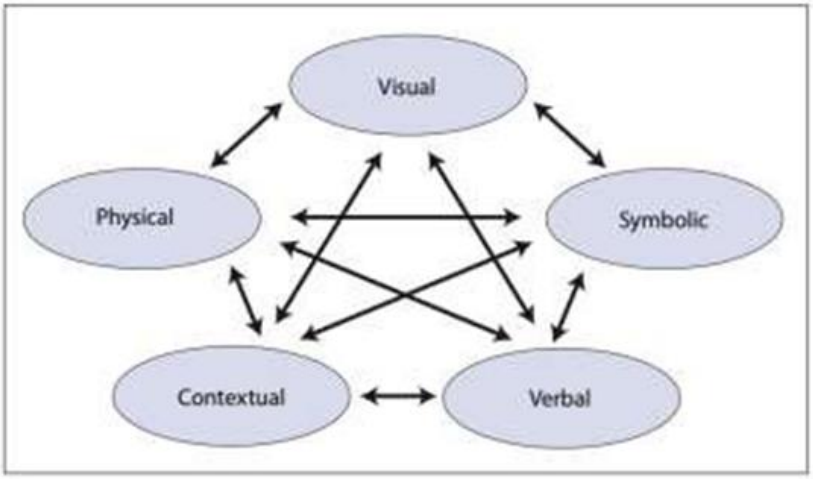
3. Facilitate student discussion

Once the students are assigned tasks, they should be encouraged to discuss with their group and seek each other's' support. To have effective group discussions, it is important for a teacher to set norms in the classroom where every voice is heard, and students respect and value each other.

As the students are engaged in problem-solving and discussion, the teacher can act as a facilitator, listen to math talk, and observe emerging strategies. Teachers should make sure that they allow the students to attempt the task themselves and learn through their mistakes. Guiding the student through every step of the problem or telling them the answers will not allow the students to develop a deep understanding of the topic. Instead, questions can be posed that guide them to think critically and provide justification for their work. A monitoring sheet can be used to note down the different strategies students are coming up with and select some student work that can be presented to the whole class for a reflective discussion.

4. Connect mathematical ideas

After students are done with solving the problem, or as appropriate, teachers can bring the whole class together for a discussion. The selected students can be asked to present their strategies and/or solutions. The mathematical content of the shared work should be sequenced in a way that connects different representations and ideas together. Some of the connections that can be made between different representations are highlighted by this diagram:



Taken from NCTM (2014)

The discussion should also tie back to the lesson goals, help students build conceptual understanding from procedural fluency, and spark curiosity, intrigue, and interest in them.

5. Reflect and adapt

Once the lesson is over, teachers should take out some time to reflect on what went well, what could have gone better, and what were some of the challenges that they faced. They should also reflect on the student responses and feedback to assess student understanding and tailor content for the next lessons. Particular strategies for formative assessment that allow this kind of feedback cycle are discussed in the Assessment Practices below.

On Use of Educational Mathematics Software

Use of educational mathematics software (such as Desmos, Maple and GeoGebra) is encouraged, but not compulsory. This is keeping in line with international best practices regarding flexible and dynamic teaching approaches.

ASSESSMENT PRACTICES

Assessments are an important part of the teaching and learning cycle. However, usually assessments are only focused on measuring student achievement, instead of also acting as a means of feedback to improve teaching and learning. Assessments should serve four functions in mathematics classrooms:

- Track students' progress to enhance student learning.
- Adjust teaching practices to enhance student understanding.
- Assess student performance to summarize and report on their understanding at a specific point in time.
- Assess educational programs to make decisions regarding their effectiveness.

Types of Assessments

Assessments can be broadly divided into two categories: Assessment for learning (i.e., Formative Assessment) and Assessment of Learning (i.e., Summative Assessment).

1. Formative assessment refers to the ongoing assessment of student learning and progress, typically taking place during the learning process. The purpose of formative assessment is to provide feedback to students and teachers to inform ongoing instruction and improve student learning. Formative assessments are informal, typically done in class and not graded, and are used to identify students' strengths and weaknesses, adjust instruction accordingly, and inform future learning goals.

2. Summative assessment refers to the evaluation of student learning and achievement at the end of a unit, term, or course. The purpose of summative assessment is to evaluate the extent to which students have met specified learning objectives and provide a final grade or overall score. Summative assessments are formal, often take the form of tests and exams, and are used to provide evidence of learning and student achievement over a set period of time. They are typically the basis for final grades and are used to make decisions about student promotion, placement, and graduation.

Both the formative and summative assessments should include a range of questions that test students on multiple levels. More focus should be on open-ended questions that allow multiple strategies and solutions, and do not have a specific right or wrong answer. They provide students with the opportunity to demonstrate conceptual understanding, and encourage critical thinking, creativity, and problem-solving skills. Closed-ended questions, on the other hand, often have a specific set of answers and there is only one right answer. They test the student's knowledge and recall of specific mathematical concepts and formulas.

Rubrics and Grading

An important measurement tool for both formative and summative assessment is rubrics. They allow for a structured way to gauge student performance and score their work instead of grading haphazardly, which helps minimize subjectivity in grading as well. If multiple graders are grading the same assignment, having a rubric also helps maintain consistency across the student grading. It further helps teachers plan ahead and know what they expect from their students. And although creating a rubric takes time, once it is created, general rubrics can be used for multiple tasks and specific rubrics can be used to grade the same tasks again, so in the longer run, they can help save time.

Rubrics are also beneficial for the students as they outline what is expected from them. Knowing beforehand what they are being assessed on can help students strive for that goal. It also helps them self-assess themselves as they can monitor their progress and see where they fall according to the rubric and what is needed for them to reach the higher levels of the rubric. Moreover, having a rubric sends out the message to the students that they are not just being graded on a correct answer, but instead it is the quality of their work which includes their understanding of the concept that matters too.

Rubrics can take many forms, depending on the task and objective. You can break down a student's performance into separate criteria and assign a score to each or evaluate the task given as a whole. There can even be task-specific rubrics or general rubrics that can be used for multiple tasks.

Formative Assessment Plan

The learning activities given in the Curriculum Guide can be used as formative assessments to gather evidence of student learning and give students the opportunity to measure their own growth and reflect and articulate key ideas. Here is a sample formative assessment plan that can be adapted by teachers, consisting of multiple assessment strategies. Teachers can pick a few from these for each unit that they cover.

1. **Pre-assessment/Diagnostic**: Before starting a new topic, administer a pre-assessment to gauge students' current understanding and identify areas where they may need extra support. This can take the form of a diagnostic quiz, exit ticket, or quick poll.

2. **Classroom Discussions:** Encourage students to participate in regular class discussions, either in small groups or as a whole class. Ask questions, listen to students' responses, and provide feedback on their understanding. These discussions provide an opportunity to check for understanding, encourage critical thinking, and identify areas where students need further clarification.

3. **Quizzes:** Give quizzes or short assessments on the material covered in class. These can be conducted within a unit to assess individual student's understanding of the mathematical ideas across lessons. These quizzes should consist of different types of questions that assess different levels of cognitive demand to push students to think, create, connect, and analyze. A rubric can be provided to students with the quizzes and can be used by the teacher to assess these quizzes. The scores will help inform what misconceptions the students have, or what is some idea they are lacking a proper understanding of, so that the teacher can revise or revisit them during the unit.

4. **Group project:** Occasionally, at the end of a unit, students can be given group projects that require them to apply their knowledge and work together to solve problems. For example, one project might consist of presenting and comparing the three ways to solve systems of equations. Provide the students a rubric before assigning each project and make sure they understand it. Halfway through the project, ensure that the students use the rubric to check their progress. Then use the rubric to score the projects after they have completed them, and provide them with the scores they earned based on the rubric. Offer them opportunities to earn more points by correcting any mistakes.

5. **Performance Assessment:** During the lesson, give students open-ended and authentic tasks to demonstrate their mathematical understanding. These tasks will be either individual assessments or group tasks that will be cognitively demanding but low floor and high ceiling

problems that will allow students to apply the knowledge they learnt during the lesson and further their understanding. Do not collect this work but instead monitor what the students are doing. Students can be given a rubric to help them self-assess or peer-assess these tasks.

6. **Classroom observations:** While the students are solving tasks and having discussions within groups, roam around the class observing their written work and listening to their conversations. Use a monitoring sheet with student's names on them to record which student is using which strategy and keep a check of the different ideas that are being formulated. Help direct the students' thinking by asking them questions that will push them to critically think. The notes can then be used to sequence ideas and pick particular students to present strategies to discuss in a whole-class discussion to help all students connect between different ideas.

7. **Math Journals:** Encourage students to reflect on their learning and set goals for improvement by writing them in their journals. Have students answer an open-ended question in a journal (like what did you learn today? Or what questions would you like me to answer tomorrow?) and select a few students to share. Reflection helps students see their progress, identify areas for improvement, and take ownership of their learning.

8. **Gallery walk:** Have students respond to questions about the classroom and respond to the ideas of others. Have students work on different tasks in groups and then create a visual display that summarizes their work and understanding of the topic. These displays can be placed around the classroom and have students walk around and interact with each display. They can ask questions, make observations, and give feedback to their peers using post-it notes. After the gallery walk, lead a discussion to debrief the experience. Students reflect on what they learned from their peers, what they found most helpful, and what areas they still need to work on. Instead of student work displays, myths about a certain topic can also be placed around the classrooms and students asked to walk around and respond to the prompts as a group.

9. **Jigsaw:** Have students work in groups to solve a mathematics problem or concept. Each group is responsible for a specific part of the problem or concept, and then mix students up and have them share their findings and ideas to their new group. This process allows students to practice their problem-solving and critical thinking skills, as well as their ability to collaborate and communicate effectively with their peers. The teacher can observe and listen to the students during the activity, and use the information gathered to assess their understanding of the topic being covered and make any necessary adjustments to their instruction.

10. **Exit Tickets**: At the end of most lessons, have students individually complete and hand in an exit ticket. The exit ticket will consist of 1-3 questions ranging from closed questions to assess student's procedural fluency, open-ended questions to assess student's conceptual understanding, questions similar to the tasks done in class to allow students to apply the knowledge they learnt and questions to have them inform the teacher about any confusions/questions that they might still have. These exit tickets will be used to inform the teacher about individual student's current understandings and help him/her tailor the content of the next lesson to suit the students' needs.

11. **Homework**: Occasionally, give students homework to allow them to practice what they learnt during class. The homework questions will also be tasks that allow a deeper level of thinking instead of closed questions that have only one accurate answer. Students can choose a homework buddy to ask for help with homework assignments and they will be encouraged to

identify concepts they are struggling with. Homework might only be given a couple of times in a unit to not overburden students, but it will help students self-assess themselves and revisit the concepts discussed in class. At the beginning of the class following a class where a homework was assigned, have a brief discussion that draws connections across homework problems, talks about the challenges students faced, or asks students the justification behind their solving techniques.

The Traditional Examinations

Bearing in mind the requirement of simplicity in considering assessment strategies, the examinations in traditional paper-based mode with place and time-specific activities, are easy to organize for institutions (Boards of Intermediate and Secondary Education). When a formal examination, for Secondary School Certificate (SSC) or Higher Secondary School Certificate (HSC), is used for assessment there are examination centres, infrastructure to supply and secure examination papers before examination and arrangements to check the identities of the candidates, invigilate the examination and collect the scripts for marking. Marks are then gathered and results are promulgated in a timely manner.

In essence an effective learning-outcomes-oriented quality assurance system must be based on constant monitoring and effective feedback loops.

Instructions for SSC and HSC examinations.

The examining institutions or bodies including all Boards of Intermediate and Secondary Education for the conduct of SSC and HSC examinations in the subject of Mathematics should follow instructions as given below;

- The question papers should be balanced in all respect.
- The weightage to difficulty level of questions is suggested to be a practicable criterion for a balanced question paper of Mathematics, i.e. difficulty Level of Questions Weightage Easy 1 6%, Average 68 %, Difficult 16 %.

UNIT WISE WEIGHTAGES – GRADE- IX

Sr#	Unit Title	Weightage
1.	Real Numbers	16.32 %
2.	Sets and functions	12.24 %
3.	Factorization	10.20 %
4.	Linear Equation and Inequalities in one/two variable	4.08 %
5.	Co-ordinate Geometry	10.20 %
6.	Similar figures	4.08 %
7.	Geometrical Properties of Regular Polygons, Triangles and Parallelograms	2.04 %
8.	Loci	2.04 %
9.	Trigonometry	10.20 %
10.	Bearings	4.08 %
11.	Construction of Triangle	8.16 %
12.	Frequency Distribution	2.04 %
13.	Measure of Central Tendency	4.08 %
14.	Probability	4.08 %
15.	Relative and expected frequencies.	6.12 %
	Total	**100 %**

UNITWISE WEIGHTAGES – GRADE- X

Sr#	Unit Title	Weightage
1.	Complex numbers	8.33 %
2.	Matrices and determinants	6.25 %
3.	Functions and Graphs	9.37 %
4.	Algebraic fractions	6.25 %
5.	Linear Inequities in two variables	2.08 %
6.	Quadratic Equations	13.54 %
7.	Co-ordinate Geometry	4.17 %
8.	Angle between Lines	3.13 %
9.	Vector Plan	9.37 %
10.	Application of Trigonometry	3.13 %
11.	Chords and Arcs of a circle	10.42 %
12.	Tangent and angles of a Circle	9.37 %
13.	Practical Geometry of Circles	3.13 %
14.	Tangent of the Circle	4.17 %
15.	Cumulative Frequency Distribution and measures of dispersion	5.21 %
16.	Probability of combined events	2.08 %
	Total	**100 %**

UNITWISE WEIGHTAGES – GRADE- XI

Sr #	Unit Title	Weightage
1.	Complex Numbers	17.65 %
2.	Matrices & Determinants	11.76 %
3.	Sequences and Series	8.24 %
4.	Mathematical Induction	3.53 %
5.	Binomial Theorem	9.41 %
6.	Division of polynomial	5.88 %
7.	Vector in space	18.82 %
8.	Scalar triple product	8.24 %
9.	Fundamental law of Trigonometry	3.53 %
10.	Trigonometric Functions	3.53 %
11.	Graphs and Trigonometric Functions	3.53 %
12.	Permutation and Combination	4.70 %
13.	Laws of Probability	1.18 %
	Total	**100 %**

UNITWISE WEIGHTAGES – GRADE- XII

Sr #	Unit Title	Weightage
1.	Functions and Graphs	15.69 %
2.	Limit and continuity of a function	5.88 %
3.	Introduction of Differentiation	6.86 %
4.	Application of Derivatives	8.83 %
5.	Vector valued function	4.90 %
6.	Integration	12.75 %
7.	Mechanics Kinematics of motion in a straight line	1.96 %
8.	Differential Equations	6.86 %
9.	Numerical Solution of nonlinear Equations	2.94 %
10.	Analytical Geometry concurrency of straight lines	6.86 %
11.	Conics	19.61 %
12.	Inverse Trigonometric Functions	6.86 %
	Total	**100 %**

TEACHING AND LEARNING RESOURCES

Guidelines to Textbook Authors Textbooks aimed at lower levels tend to be inclined more towards learning features than those at higher levels. However, in textbooks writing generally the following aspects may be taken into considerations.

- All exercises of the textbook may contain maximum number of applied problem (more than 50 %).
- Each topic be explained clearly with solved real-life problem.
- The text book should be in line with the weightage, of the topics, areas of curriculum and Students Learning Outcome (SLO) of the Reviewed curriculum.
- The authors should continuously focus on the standards and benchmarks and Students Learning Outcome (SLO).
- The author must bring himself to mental level of the students he/she is writing for.
- The span of the text book be fairly reasonable. Use previous concepts and extend for the higher one.
- The material be cramped to make it more digestible; it may be chunked into smaller parts with headings.
- The textbook must provide accurate and up-to-date information.
- The text material be arranged in a logical manner i.e. simple to complex, familiar to unfamiliar and concrete to abstract.
- The text material must be free from ambiguities and errors (both conceptual and typographical).
- The content provided in the text book should not develop wrong and confusing concepts.
- The text be clear and concise. It may not convey any meaning other than the one intended in the curriculum SLO.
- Special attention be paid to geometrical notions; every table; line drawings and graphs and diagrams should be labeled appropriately.
- Footnotes and side notes may be inserted whenever necessary, and website related to the topic be highlighted for further studies.
- Workout/solved examples should be lucid with solutions in details, giving reasons related to particular ensuing problems in the exercise.
- A simple and brief exercise be given on the previous work related to the topic in order to maintain continuity.
- List of symbols and index be given at the end of the book to facilitate the students and the teachers.
- The authors should go through relevant curriculum and the guidelines to the authors before developing the textbooks.
- The authors are requested to provide the answers of the questions given in the exercises of the books so that discrepancies are avoided.
- Objective type, multiple choice questions (MCQs) may be given at the end of every chapter.
- Miscellaneous exercise may also be given at the end of each chapter.
- Emphasis should be on applications of the concepts and techniques developed in the text rather than on the memorization system.

Textbook style and structure

To make a textbook an effective teaching and learning tool its style and structure is given due importance. The material needs to be structured in a coherent and logical way, and that writing style should be reader friendly.

Unit Opening	
Unit Outline	Include list of headings/SLOs
Student Learning Outcomes (SLOs)	Include all SLOs of the respective unit.
Real Life Relevance	Illustrate the real-life relevance of the unit as the STEAM.
Short Introduction	Explain what this unit covers and why.
Unit Body	
Key Terms	Use italics for emphasis and bold for key terms. Define key terms when first introduced and collate them with their definitions for the glossary.
Running Glossary	Key terms and definitions may be pulled out from the main body of text so that students spot them easily in the unit body (e.g. in the margins).
Feature Boxes	Regular feature boxes may include various contents such as a mathematical formula, a working rule or a statement of theorem.
Illustrative Examples	Include illustrative examples to develop conceptual understanding of the topic.
Problem Sets	Special attention should be paid on preparation of Problem Sets. Correlate Mathematics with real life situations and include sufficient exercises on real life problems almost in every problem set, if appropriate. The questions on the application of Mathematics in other fields of study are also very useful.
Learning Review Points	Include bulleted questions for students to check their understanding at regular intervals. Possible labels include ‘self-test point’ or ‘checkpoint’.
Tips or Hints	Separated from the main body of text, they allow the author to speak directly to the student, offering useful advice or flagging important points.
Visuals	Separated from the main body of text, they allow the author to speak directly to the student, offering useful advice or flagging important points. Tables, graphs, line drawings and lists may be used to break up the text.
Unit Ending	
Problem Set (Review)	Include multiple-choice questions, interpretive exercises and fill-in items. Students may also be asked to label diagrams or write a one-word answer to short question.
Summary	Include a review of the main concepts. This can relate to the SLOs by covering each in turn (bullet points work well). The summary should not include any new information.

Guidelines for the Teachers' Manual

Ideally the teachers' manual should come with the textbook. The manual is aimed at informing teachers how the textbook is written and how best to use it to facilitate student learning. It can be seen as a means of helping teachers to develop professionally. It should provide detailed explanation of key concepts and the way to teach a particular topic. Its basic features are as below;

The teachers' manual should

- Be easy to understand and use.
- Help teachers develop instructional material, strategies, teach the text in class and extend activities.
- Given sequenced instructions for each activity.
- Include teaching learning resources and identify the sources.
- Establish a question bank (having questions different from text) and suggest interactive quizzes corresponding to each unit.
- Involve variety of updated and relevant teaching strategies and rationale for their use.
- Explain how to implement each teaching strategy.
- Identify constraints and strength of each strategy or activity.
- Identify resources needed for teaching strategies and extension of activities.
- Expand and develop teachers' rationale of knowledge and skills.
- Identify assessment strategies.
- Orientation of authors and reviewers be arranged for a better cohesion.
- Teachers' manual should be made available along with the textbook.
- Real life examples be given for the concepts, i.e. use of matrices. Connectivity of STEAM with various stations/cities, manufacturing of different products, census data, etc.

General Guidelines to Textbook Board

- Orientation sessions/workshops may be arranged for respective teachers to apprize them of the curriculum and relevant textbook.
- The Text Book Boards must ensure that the relevance of the curriculum and textbooks is maintained, the language should be simple and the material be students' friendly.
- The Textbook Boards should arrange the orientation sessions for authors and reviewers for better understanding of the curriculum.
- The reviews of the textbooks be periodically conducted by senior and more qualified teachers and published for improvement of the textbooks.

The web-based resources

The use of World Wide Web (www) is growing very fast to access an immense volume of rapidly evolving information. It is acting as a driving force since its ease of use makes the internet trivially accessible to the students even with a little knowledge of computer. Through web-based links as mentioned along with the learning outcomes will provide.

- access to various sites of Mathematics around the world, view of three-dimensional figures, graphics, lesson plans, activities and various books of interest

A + Math	http://www.aplusmath.com/
AAA Math	http://www.aaamath.com/
Academic Info-Mathematics	http://www.academicinfo.com.net/math.html
Algebra Buster	http://www.algebra-online.com
Algebra Helper	http://www.algebrahelp.com/index.jsp
Class zone	http://www.classzone.com/math_middle.cfm
Click on Bricks	http://kathyschrock.net/clickon brickindex2.html
Cool Math	http://www.coolmath.com/
Discovery School (Mathematics)	http://school.discovery.com/lessonplans/math.html
Frank Potter's Science Gems-Mathematics	http://www.sciencegems.com/math.html
Funbrain	http://www.funbrain.com/numbers.html
Geometry	http://www.mathleague.com/help/geometry/geometry.html
Internet Mathematics Library	http://www.mathforum.org/library
Math Archives	http://www.archives.math.utk.edu
Math Glossary	http://harcourtschool.com/glossary/math_advantage
Math Goodies	http://www.mathgoodies.com
Math World	http://www.mathworld.wolfram.com
Math2	http://www.math2.org/
MATHEMATICA	http://www.wolfram.com/products/mathematica/index.html
Mathematical Interactivities	http://mathematics.hellam.net/
Math Stories	http://mathstroies.com
Mega Mathematics	http://www.c3.lanl.gov/mega-math/
Purple math	http://www.purplemath.com/internet.html
S.O.S. Mathematics	http://www.sosmath.com
Superkids Educational Software Review	http://www.superkids.com/aweb/tools/math/index.shtml
Teaching made Easier	http://www.teachingmadeasier.com/math.html
The math Works (MATLAB)	http://www.mathworks.com
Web math	http://www.webmath.com

ACKNOWLEDGMENT

Mathematics Curriculum	Experts	Year
National Curriculum of Pakistan	Writing and framework team, and panel of experts	**2022-23**
Curriculum for Mathematics Grades XI-XII (Revised in 2019)	Writing and framework team, and panel of experts	**2019**

PROVINCIAL REVIEW COMMITTEE MATHEMATICS 2023-24

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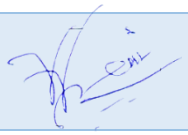
4	Prof: Dr. Rahim Bux Khokhar, Mehran University of Engineering Jamshoro	Member	
5.	Prof: Dr. Abdul Wasim Shaikh, Sindh University Jamshoro	Honorary Member	
6	Pro: Dr Sania Qureshi, MUET Jamshoro	Honorary Member	
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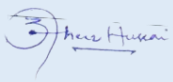
9	Mr. Zaheer Hussain Abbassi, Subject Specialist, DCAR, Jamshoro	Member	
10	Mr. Zohaib Haseeb, Assistant Professor, DETRC Latifabad, Hyderabad	Member	
11	Mr. Kamran Latif, Assistant Subject Specialist, Sindh Textbook Board, Jamshoro	Member	
12	Mr. Abdul Majeed Khoso, Lecturer, MUET Jamshoro	Co-opt Member	
13	Mr. Ahmed Khan Zaur, Deputy Director, DCAR Jamshoro	Member/Secretary	

GOVERNMENT OF SINDH
SCHOOL EDUCATION & LITERACY DEPARTMENT

Karachi, dated the 5th, July 2024.

NOTIFICATION

NO. SELD/HCW/18/2018: In compliance with the Section 3, sub-section (4), (e) of Sindh School Education Standards & Curriculum Act 2014, Sindh Act No. IX of 2015. School Education & Literacy Department, Government of Sindh is pleased to accord **No Objection Certificate** for approval of revised **Sindh Curriculum for Mathematics 2023-24 for Grade IX-XII,** aligned with the adopted Standards of National Curriculum of Pakistan (NCP) 2022-23, after review by the Provincial Review Committee constituted for Mathematics Curriculum 2023-24.

- ZAHID ALI ABBASI-
SECRETARY TO GOVERNMENT OF SINDH

NO. SELD/HCW/18/2018: **Karachi, dated the 5th, July 2024.**

A copy for information and necessary action to:

1. The Chairman, Sindh Textbook Board, Jamshoro.
2. The Chief Advisor Curriculum Wing, School Education & Literacy Department, Government: of Sindh, Karachi.
3. The Director, Directorate of Curriculum, Assessment & Research, Jamshoro.
4. The P.S to Secretary School Education & Literacy Department, Government: of Sindh, Karachi.
5. The official website.
6. The office file.

05/07/2024.
SECTION OFFICER (A&T-I)
For SECRETARY TO GOVERNMENT OF SINDH.

SCHOOL EDUCATION & LITERACY DEPARTMENT
GOVT. OF SINDH