**Alabama Mathematics**

# Grades 9-12: Precalculus

Adopted 2019

**Precalculus**

**Number and Quantity**

A. Perform arithmetic operations with complex numbers. PC.NQ.A

1. Define the constant e in a variety of contexts. PC.NQ.A.1

   a. Explore the behavior of the function y = e<sup>x</sup> and its applications. PC.NQ.A.1.A

   b. Explore the behavior of ln(x), the logarithmic function with base e, and its applications. PC.NQ.A.1.B

2. Find the conjugate of a complex number; use conjugates to find moduli and quotients of complex numbers. PC.NQ.A.2

B. Represent complex numbers and their operations on the complex plane. PC.NQ.B

3. Represent complex numbers on the complex plane in rectangular and polar form (including real and imaginary numbers), and explain why the rectangular and polar forms of a given complex number represent the same number. PC.NQ.B.3

4. Represent addition, subtraction, multiplication, and conjugation of complex numbers geometrically on the complex plane; use properties of this representation for computation. PC.NQ.B.4

5. Calculate the distance between numbers in the complex plane as the modulus of the difference, and the midpoint of a segment as the average of the numbers at its endpoints. PC.NQ.B.5

C. Use complex numbers in polynomial identities and equations. PC.NQ.C

6. Analyze possible zeros for a polynomial function over the complex numbers by applying the Fundamental Theorem of Algebra, using a graph of the function, or factoring with algebraic identities. PC.NQ.C.6

D. Understand limits of functions. PC.NQ.D

7. Determine numerically, algebraically, and graphically the limits of functions at specific values and at infinity. PC.NQ.D.7

   a. Apply limits of functions at specific values and at infinity in problems involving convergence and divergence. PC.NQ.D.7.A

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E. Represent and model with vector quantities. PC.NQ.E

8. Explain that vector quantities have both magnitude and direction. Represent vector quantities by directed line segments, and use appropriate symbols for vectors and their magnitudes. PC.NQ.E.8

9. Find the components of a vector by subtracting the coordinates of an initial point from the coordinates of a terminal point. PC.NQ.E.9

10. Solve problems involving velocity and other quantities that can be represented by vectors. PC.NQ.E.10

11. Find the scalar (dot) product of two vectors as the sum of the products of corresponding components and explain its relationship to the cosine of the angle formed by two vectors. PC.NQ.E.11

F. Perform operations on vectors. PC.NQ.F

12. Add and subtract vectors. PC.NQ.F.12

    a. Add vectors end-to-end, component-wise, and by the parallelogram rule, understanding that the magnitude of a sum of two vectors is not always the sum of the magnitudes. PC.NQ.F.12.A

    b. Given two vectors in magnitude and direction form, determine the magnitude and direction of their sum. PC.NQ.F.12.B

    c. Explain vector subtraction, v – w, as v + (–w), where –w is the additive inverse of w, with the same magnitude as w and pointing in the opposite direction. Represent vector subtraction graphically by connecting the tips in the appropriate order, and perform vector subtraction component-wise. PC.NQ.F.12.C

13. Multiply a vector by a scalar. PC.NQ.F.13

    a. Represent scalar multiplication graphically by scaling vectors and possibly reversing their direction; perform scalar multiplication component-wise. PC.NQ.F.13.A

    b. Compute the magnitude of a scalar multiple cv using $||cv|| = |c|v$. Compute the direction of cv knowing that when $|c|v \neq 0$, the direction of cv is either along v (for c > 0) or against v (for c < 0). PC.NQ.F.13.B

14. Multiply a vector (regarded as a matrix with one column) by a matrix of suitable dimensions to produce another vector. Work with matrices as transformations of vectors. PC.NQ.F.14