

# Higher Mathematics Course — Number and Quantity

Adopted 2010

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### The Real Number System

- A. Extend the properties of exponents to rational exponents. **HSN.RN.A**
  - 1. Explain how the definition of the meaning of rational exponents follows from extending the properties of integer exponents to those values, allowing for a notation for radicals in terms of rational exponents. **N.RN.1**
  - 2. Rewrite expressions involving radicals and rational exponents using the properties of exponents. **N.RN.2**
- B. Use properties of rational and irrational numbers. **HSN.RN.B**
  - 3. Explain why the sum or product of two rational numbers is rational; that the sum of a rational number and an irrational number is irrational; and that the product of a nonzero rational number and an irrational number is irrational. **N.RN.3**

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### Quantities

- A. Reason quantitatively and use units to solve problems. **HSN.Q.A**
  - 1. Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. **N.Q.1**
  - 2. Define appropriate quantities for the purpose of descriptive modeling. **N.Q.2**
  - 3. Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. **N.Q.3**

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## The Complex Number System

- A. Perform arithmetic operations with complex numbers. [HSN.CN.A](#)
1. Know there is a complex number  $i$  such that  $i^2 = -1$ , and every complex number has the form  $a + bi$  with  $a$  and  $b$  real. [N.CN.1](#)
  2. Use the relation  $i^2 = -1$  and the commutative, associative, and distributive properties to add, subtract, and multiply complex numbers. [N.CN.2](#)
  3. (+) Find the conjugate of a complex number; use conjugates to find moduli and quotients of complex numbers. [N.CN.3](#)
- B. Represent complex numbers and their operations on the complex plane. [HSN.CN.B](#)
4. (+) 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. [N.CN.4](#)
  5. (+) Represent addition, subtraction, multiplication, and conjugation of complex numbers geometrically on the complex plane; use properties of this representation for computation. [N.CN.5](#)
  6. (+) 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. [N.CN.6](#)
- C. Use complex numbers in polynomial identities and equations. [HSN.CN.C](#)
7. Solve quadratic equations with real coefficients that have complex solutions. [N.CN.7](#)
  8. (+) Extend polynomial identities to the complex numbers. [N.CN.8](#)
  9. (+) Know the Fundamental Theorem of Algebra; show that it is true for quadratic polynomials. [N.CN.9](#)

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## Vector and Matrix Quantities

- A. Represent and model with vector quantities. [HSN.VM.A](#)
- (+) Recognize vector quantities as having both magnitude and direction. Represent vector quantities by directed line segments, and use appropriate symbols for vectors and their magnitudes (e.g.,  $v$ ,  $|v|$ ,  $\|v\|$ ,  $v$ ). [N.VM.1](#)
  - (+) Find the components of a vector by subtracting the coordinates of an initial point from the coordinates of a terminal point. [N.VM.2](#)
  - (+) Solve problems involving velocity and other quantities that can be represented by vectors. [N.VM.3](#)
- B. Perform operations on vectors. [HSN.VM.B](#)
- (+) Add and subtract vectors. [N.VM.4](#)
    - Add vectors end-to-end, component-wise, and by the parallelogram rule. Understand that the magnitude of a sum of two vectors is typically not the sum of the magnitudes. [N.VM.4.A](#)
    - Given two vectors in magnitude and direction form, determine the magnitude and direction of their sum. [N.VM.4.B](#)
    - Understand 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. [N.VM.4.C](#)
  - (+) Multiply a vector by a scalar. [N.VM.5](#)
    - Represent scalar multiplication graphically by scaling vectors and possibly reversing their direction; perform scalar multiplication component-wise, e.g., as  $c\langle v_x, v_y \rangle = \langle cv_x, cv_y \rangle$ . [N.VM.5.A](#)
    - 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  $c < 0$ ). [N.VM.5.B](#)
- C. Perform operations on matrices and use matrices in applications. [HSN.VM.C](#)
- (+) Use matrices to represent and manipulate data, e.g., to represent payoffs or incidence relationships in a network. [N.VM.6](#)
  - (+) Multiply matrices by scalars to produce new matrices, e.g., as when all of the payoffs in a game are doubled. [N.VM.7](#)
  - (+) Add, subtract, and multiply matrices of appropriate dimensions. [N.VM.8](#)
  - (+) Understand that, unlike multiplication of numbers, matrix multiplication for square matrices is not a commutative operation, but still satisfies the associative and distributive properties. [N.VM.9](#)
  - (+) Understand that the zero and identity matrices play a role in matrix addition and multiplication similar to the role of 0 and 1 in the real numbers. The

determinant of a square matrix is nonzero if and only if the matrix has a multiplicative inverse. [N.VM.10](#)

11. (+) 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. [N.VM.11](#)
12. (+) Work with  $2 \times 2$  matrices as transformations of the plane, and interpret the absolute value of the determinant in terms of area. [N.VM.12](#)