Quadratic War

The Battle of Real and Complex Roots

Game Design & Copyright Document

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Abstract

Quadratic War is an advanced educational strategy game that bridges the gap between abstract algebraic concepts and tangible tactical gameplay. By mapping polynomial degrees to movement capabilities and using the quadratic discriminant as a combat resolution mechanism, the game builds an intuitive understanding of the nature of roots. This document serves as the official record of the game's mechanics, philosophy, and copyright.

Contents

1 Educational Philosophy **2**

2 Game Components & Setup **2**
2.1 The Battlefield 2
2.2 The Armies 2

3 Combat Mechanics: The Equation Engine **2**
3.1 Trigger Condition 2
3.2 Resolution Process 3

4 Combat Examples **3**
4.1 Example 1: The Successful Flank 3
4.2 Example 2: The Strategic Blunder 3

5 Strategic Guidelines **4**
5.1 Controlling the Determinant 4

6 Copyright & Legal **4**

1 Educational Philosophy

The core design philosophy of *Quadratic War* is the physical manifestation of mathematical properties.

- **Degrees of Freedom vs. Degree of Equation**: In mathematics, higher-degree polynomials are more complex and powerful. In the game, this is represented by movement range. A quadratic term (x^2, degree 2) has higher mobility than a linear term (x, degree 1), which in turn is more mobile than a constant (c, degree 0).
- **The Discriminant as Destiny**: Students often learn $\Delta = B^2 - 4AC$ by rote. In this game, Δ determines survival. It transforms an abstract formula into a life-or-death strategic check.

2 Game Components & Setup

2.1 The Battlefield

The game is played on a grid of **9 Rows** $\times$ **8 Columns**.

- Players start at opposite ends of the board.

2.2 The Armies

Two players, **Red** and **Blue**, each command an army of algebraic terms.

Piece Types & Movement Classes

- **The Constant (c)**: *Degree 0.*
  - **Movement**: 1 square forward vertically.
  - **Role**: The infantry. Slow, but essential for forming valid equations.
- **The Linear (bx)**: *Degree 1.*
  - **Movement**: Up to 2 squares in Cardinal directions (Horizontal/Vertical).
  - **Role**: The cavalry. Flexible connectors that bridge the gap between heavy hitters and support.
- **The Quadratic (ax^2)**: *Degree 2.*
  - **Movement**: Up to 3 squares in Any direction (Cardinal + Diagonal).
  - **Role**: The artillery. powerful, long-range units that dictate the flow of battle.

Note: Pieces cannot jump over other pieces.

3 Combat Mechanics: The Equation Engine

Unlike traditional games where capture is by displacement, capture in *Quadratic War* is by **Alignment and Calculation**.

3.1 Trigger Condition

Combat is triggered automatically at the end of a turn if:

1. A contiguous line of **2 or more pieces** is formed (Horizontal, Vertical, or Diagonal).
2. The line contains pieces from **both players**.

3.2 Resolution Process

When a valid chain is detected, the game "solves" the skirmish:

Step 1: Coefficient Summation
All terms in the chain are summed to create a single quadratic equation of the form:

$$Ax^2 + Bx + C = 0$$

Where:

- $A = \sum$ Coefficients of x^2 terms.
- $B = \sum$ Coefficients of x terms.
- $C = \sum$ Constant terms.

Step 2: The Discriminant Check
Calculate the discriminant:

$$\Delta = B^2 - 4AC$$

Step 3: The Outcome

Scenario A: Real Roots ($\Delta \geq 0$)
The equation yields real solutions. The attack is **VALID**.
Result: OPPONENT'S pieces in the chain are ELIMINATED.

Scenario B: Complex Roots ($\Delta < 0$)
The equation yields complex (imaginary) solutions. The attack **FAILS**.
Result: ACTIVE PLAYER'S pieces in the chain are ELIMINATED (Self-Destruct).

4 Combat Examples

4.1 Example 1: The Successful Flank

Red moves a $-4x$ next to Blue's $2x^2$ and 2.

- **Chain**: $\{2x^2(\text{Blue}), -4x(\text{Red}), 2(\text{Blue})\}$
- **Equation**: $2x^2 - 4x + 2 = 0$
- **Coefficients**: $A = 2, B = -4, C = 2$
- **Discriminant**: $\Delta = (-4)^2 - 4(2)(2) = 16 - 16 = 0$
- **Result**: $\Delta \geq 0$. Real Roots. **Red wins**. Blue's $2x^2$ and 2 are removed.

4.2 Example 2: The Strategic Blunder

Blue moves a 1 (Constant) to block Red's x^2.

- **Chain**: $\{x^2(\text{Red}), 1(\text{Blue})\}$
- **Equation**: $1x^2 + 0x + 1 = 0$
- **Coefficients**: $A = 1, B = 0, C = 1$

- **Discriminant**: $\Delta = 0^2 - 4(1)(1) = -4$
- **Result**: $\Delta < 0$. Complex Roots. **Blue fails**. Blue's own piece (the 1) is removed due to instability.

5 Strategic Guidelines

5.1 Controlling the Determinant

Victory lies in manipulating $B^2 - 4AC$.

- **To Attack**: Maximize B^2 or make AC negative.
- **To Defend**: Force your opponent into situations where AC is large and positive, and B is small.

The "Sign" Rule: If A and C have opposite signs (e.g., $2x^2$ and -5), then $-4AC$ becomes positive. Δ will *always* be positive. *Strategic Implication*: Attacking an opponent's positive quadratic with a negative constant is always a safe, successful move.

6 Copyright & Legal

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