

# Leiserchess 2023

## A Laser-Chess Game

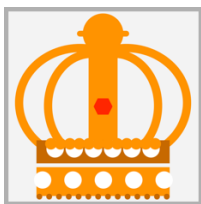
Charles E. Leiserson and the MIT 6.106 Staff  
November 13, 2023

**Leiserchess** (pronounced “LYE-sir-chess”) **2023** is a two-player laser-chess game similar to [Laser Chess](#), [Khet](#), and previous versions of Leiserchess. The teaching staff of the MIT class 6.106 *Software Performance Engineering* developed Leiserchess 2023 (henceforth just Leiserchess) for the term final project in Fall 2023. The students are given a working implementation of a Leiserchess bot, and their job is to make it run as fast as possible and otherwise improve its playing ability.

On the surface, Leiserchess is much simpler than Laser Chess or Khet. There are only two kinds of pieces — Monarchs and Pawns — and all pieces can only move to adjacent squares. A deeper complexity arises from the dynamics of how pieces interact, however, because the Monarchs carry lasers to shoot at each other and at each other’s Pawns. The result is an entertaining and challenging game that involves both tactics and strategy.

### Pieces and Board

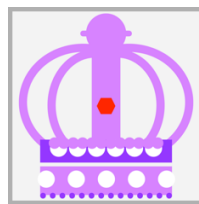
Leiserchess is played by two players, **Tangerine** and **Lavender**, on an 8-by-8 square board. The 64 squares of the board can be labeled using chess **algebraic notation**. From Tangerine’s point of view, the vertical columns of squares, called **files**, are labeled **a** through **h** from left to right, and the horizontal rows of squares, called **ranks**, are numbered **0** to **7** from bottom to top, thereby giving each square a unique coordinate consisting of a letter and a number. Each player starts with two Monarchs and six Pawns:



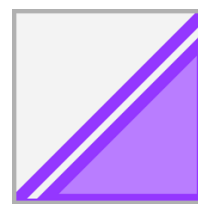
Tangerine Monarch



Tangerine Pawn



Lavender Monarch

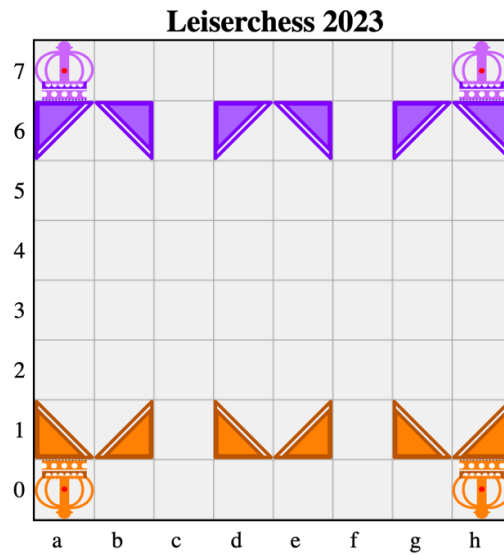


Lavender Pawn

The Monarchs contain lasers that shoot at the end of a player’s turn in the direction of the point of the crown. The hypotenusal side of a Pawn is a mirror oriented at a 45° angle to the ranks and files of the board. The Pawns’ mirrors can deflect the path of a laser beam from rank to file and vice versa. If a laser hits a Monarch or a nonmirrored side of a Pawn, that piece is **destroyed** and removed from the game.

## Opening Position

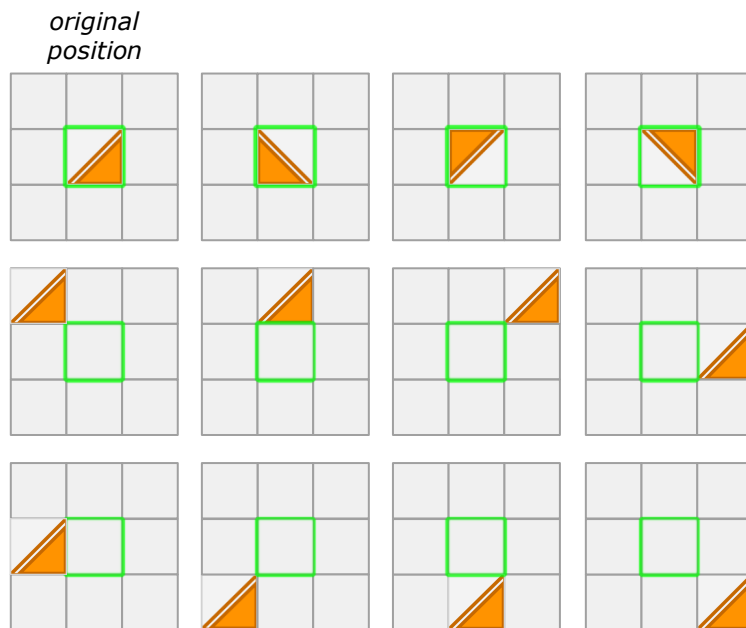
Play begins with the following starting position:



## Rules

Tangerine moves first, and then play alternates. A player may move only their own pieces. A turn has two parts: **moving** and **zapping** (firing the player's Monarchs' lasers).

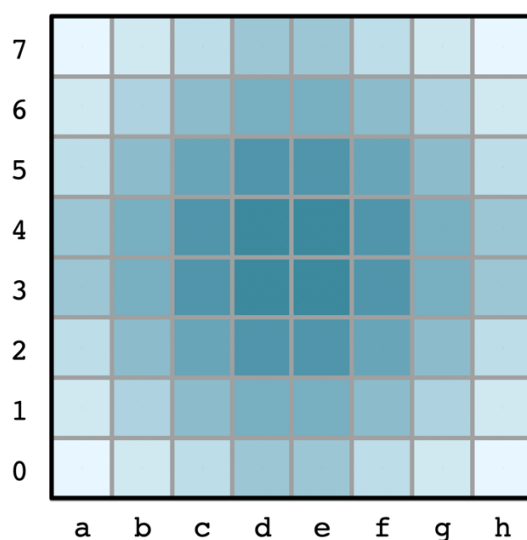
**Moving.** For the first part of a turn, the player to move chooses a piece. Each piece can either rotate by 90°, 180°, or 270°, or move to an adjacent square in any of the 8 compass directions, yielding 11 possible moves, as shown in the following figure:



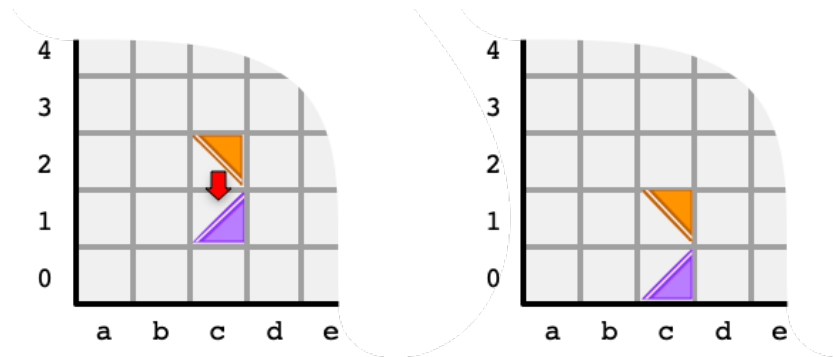
*The 11 possible moves of a Pawn.*

The player may choose not to move or rotate any piece, but only if at least one piece is zapped during the second part of the turn. In other words, the board must change as the result of this **null move**, and otherwise, the null move is illegal.

**Qi.** Each square of the board provides the Pawn on that square a mystical energy called **qi**. The amount of qi is proportional to the proximity of the square to the center of the board: the closer to the center, the more qi the Pawn occupying that square has. The following figure illustrates how much qi each square on the board provides to an occupying Pawn. Darker squares correspond to higher qi:

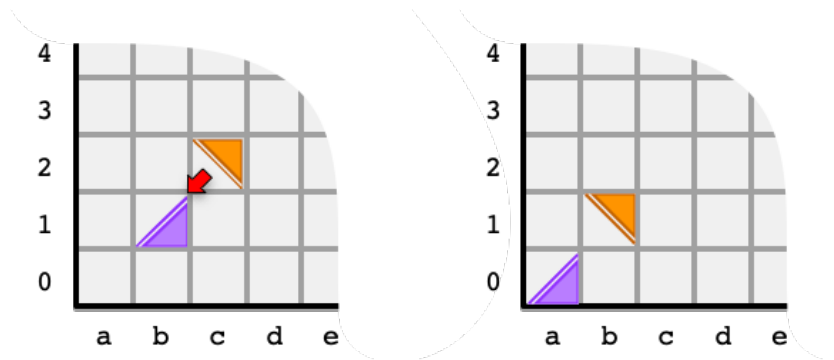


**Shoving.** If a player moves one of its Pawns onto a square occupied by another Pawn (whether the player's or the opponent's), and the first Pawn has at least as much qi as the second, then the first Pawn **shoves** the second Pawn. Shoving can occur in any of the eight compass directions. In the following figure, the position on the left is the current position:

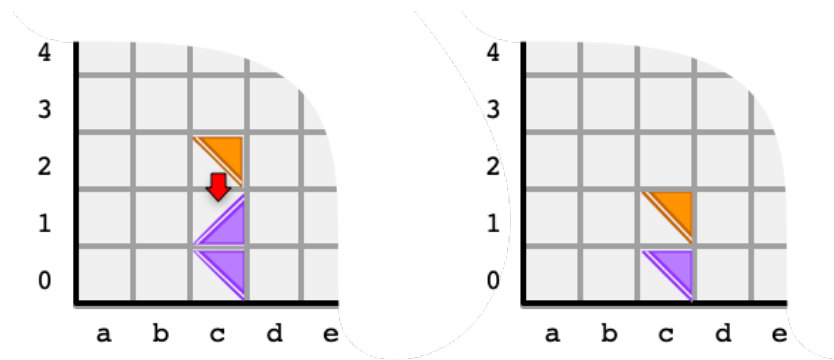


Tangerine chooses to move its Pawn on **c2** "southward" to **c1**, but since a Lavender Pawn occupies **c1**, the Tangerine Pawn shoves the Lavender Pawn. Generally, if there is an empty square on the other side of the shoved Pawn in the same direction from the shoving Pawn, then the shoved Pawn is shoved to that square. In this example, the Lavender Pawn on **c1** is shoved to **c0**, as shown in the position on the right.

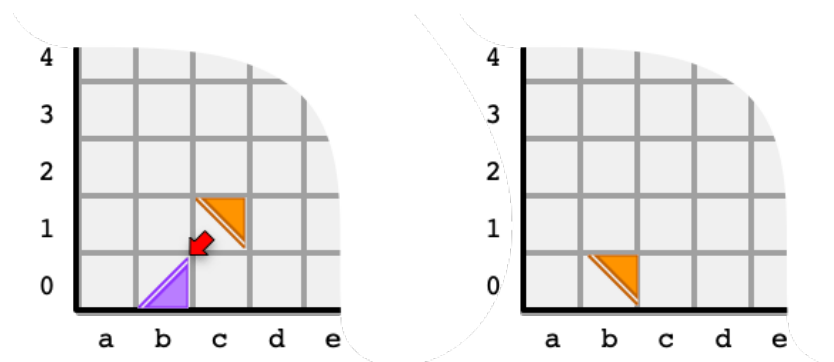
Shoving can occur diagonally as well, as shown below:



If the square on the other side of a shoved Pawn is occupied, however, then the shoved Pawn (whether yours or your opponent's) is **squashed** and destroyed. This figure provides an example:



If a Pawn on the edge of the board is shoved off the board, then the shoved Pawn is **ejected** and destroyed, like the Lavender Pawn on **b0** below:



A Pawn cannot shove a Pawn that has greater qi.

Monarchs inherently contain more qi than any Pawn and can shove any Pawn regardless of location. But Monarchs can't be shoved, either by a Pawn or by another Monarch. Consequently, they can't be ejected or squashed. The only way to destroy a Monarch is to zap it.

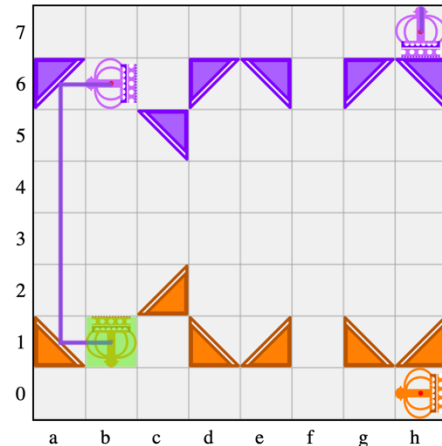
**Zapping.** For the second part of a turn, the player fires both their Monarchs' lasers, which shoot out the top of the Monarch—possibly bouncing off the mirrored surfaces of Pawns. Eventually, either the laser beam continues harmlessly off the edge of the board, or it **zaps** a Monarch or one of the nonmirrored surfaces of a Pawn. If the laser zaps a Monarch or Pawn, the piece is destroyed (beware friendly fire!).

Both of a player's Monarchs fire their lasers simultaneously. Then, if any pieces have been zapped, they are destroyed and removed from play. Zapping and laser calculations occur after any squashing or ejecting has resolved, making it possible to destroy up to three pieces in a single turn.

**Exercise:** Set up a position in which a single move can destroy three pieces.

**Winning.** You win the game if you would start your turn with more Monarchs than your opponent has. In other words, if a player zaps their opponent's Monarch, on the opponent's next turn, they must zap one of the first player's Monarchs. Otherwise, the game ends, and the opponent loses. This rule implies that if you destroy both your opponent's Monarchs, you win.

**Exercise:** In the position on the right, one of Lavender's Monarchs zaps one of Tangerine's Monarchs. Is the game over, or can Tangerine zap one of Lavender's Monarchs and stay in the game?



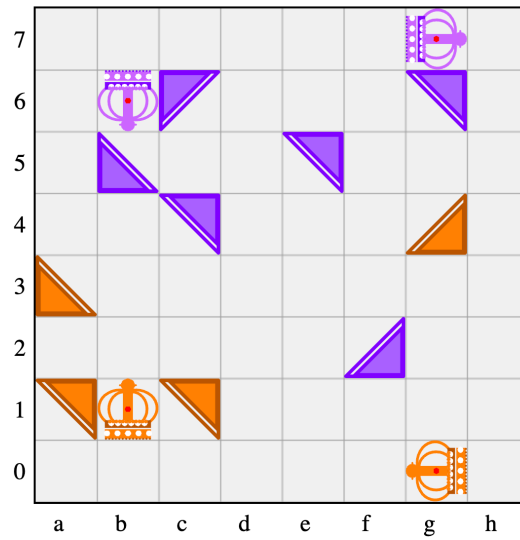
**Draws.** A draw occurs (1) if there have been 50 moves by each side without a piece being zapped; (2) if the same position repeats itself three times with the same player on move; or (3) if the two players agree to a draw. In computer play, rule (3) is usually ignored. For tournaments, the referee may also adjudicate a game as a draw if the total number of moves without a piece being destroyed exceeds a preannounced limit other than 50. Unlike Chess stalemate, no draw by a lack of legal moves can occur because a legal move is always possible.

**Time control.** As players become skilled, they tend to think longer. A chess clock (see [http://en.wikipedia.org/wiki/Time\\_control](http://en.wikipedia.org/wiki/Time_control)) can be used to keep the pace up. In 6.106, we use a Fischer clock where an increment of time is added to the clock after every move. Free chess-clock applications are available for many smart phones.

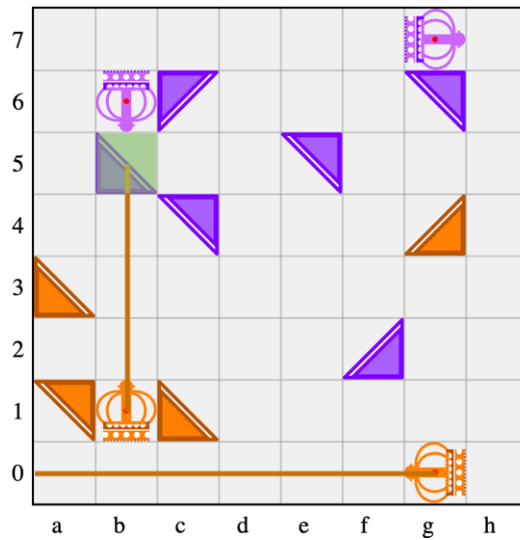
## Learning Leiserchess

To learn the game, start by clearing the board of all Pawns, and play with just one Monarchs for each player located at opposite corners of the board. You will discover that one of the two players can always force the enemy Monarch to the edge and zap it. Playing this endgame will give you a feeling for the power of the laser-slinging Monarchs. After you've mastered Monarch-on-Monarch play, you'll find it easier to learn to play the normal game, where each player has one additional Monarch, and Pawns deflect the laser beam.

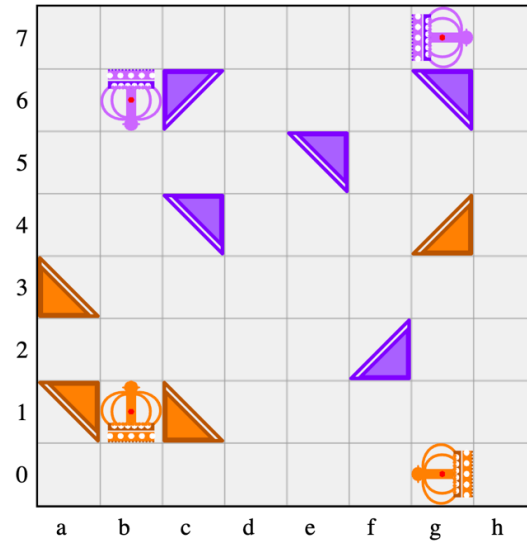
**Tactics.** Despite the simplicity of the rules, Leiserchess has remarkably interesting tactics. For a Monarch to zap an enemy Monarch, it risks opening itself up to counterattack, and so shots must be artfully composed. For example, consider the following position with Tangerine to move:



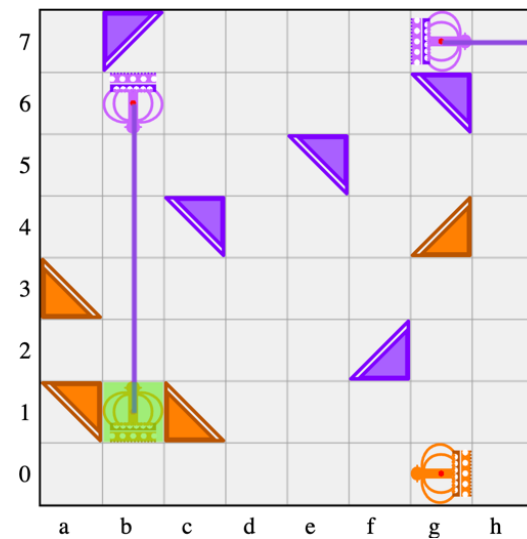
Tangerine chooses to rotate its Pawn on **c1** and zap the Lavender Pawn on **b5**:



But now, it's Lavender's turn:

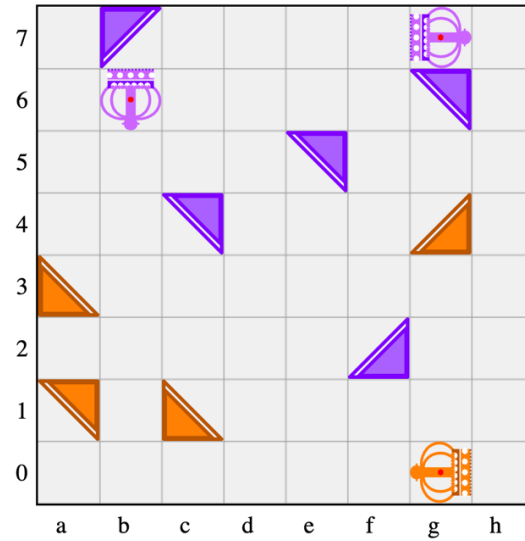


The Lavender's Monarch on **b6** has a direct shot at the Tangerine Monarch on **b1**. Although a null move would do away with the Tangerine Monarch, Lavender has a better move. Lavender counters by moving the Lavender Pawn on **c6** to **b7**, still zapping the Monarch on **b1** but, as we'll see, preventing any retaliation:

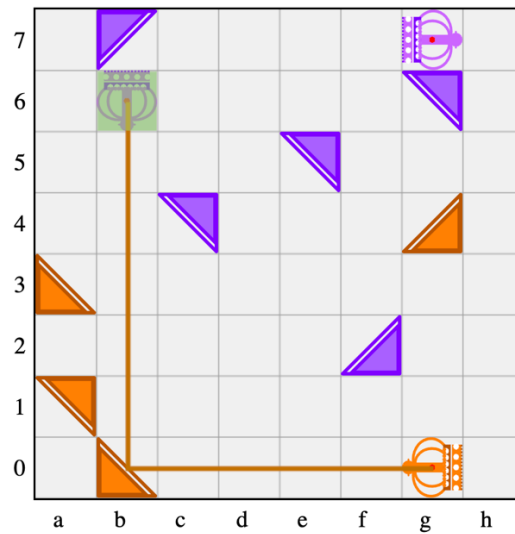


The Pawns at **c1** and **b7** serve an important purpose: they provide the opportunity to retaliate if the Monarchs on **b1** or **b6** are zapped. Now, it's Tangerine's turn again:

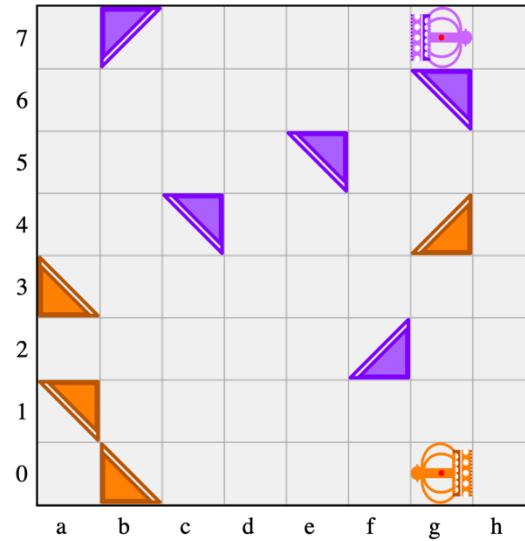




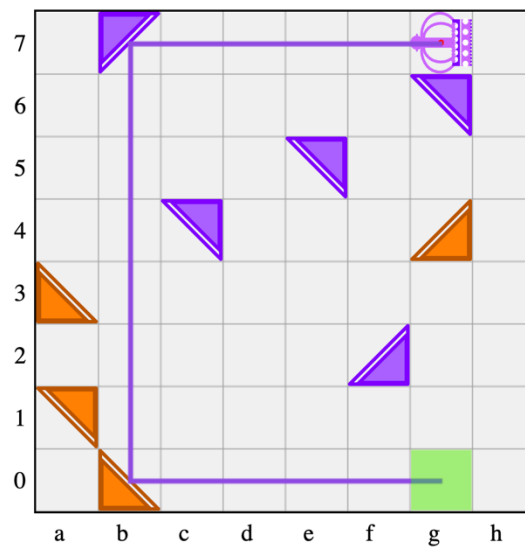
The game is over if Tangerine cannot retaliate by destroying one of Lavender's Monarchs. In that case, Tangerine's opponent would have more Monarchs at the start of Lavender's next move, which by game rules, would be a victory for Lavender. Consequently, Tangerine is forced to move the Pawn on **c1** to **b0** because that's the only way that Tangerine can destroy one of Lavender's Monarchs:



But it doesn't matter:



Lavender rotates its Monarch on **c1** 180 degrees and zaps Tangerine's last Monarch on **g0**, winning the game:



Tangerine's original move which zapped the Lavender Pawn on **b5** was profoundly unwise.

This tactical exchange illustrates the emergent complexity inherent in Leiserchess, where the interaction of simple pieces engenders complex behavior. The reverse-path nature of mirrors — "If you can see me, I can see you!" — produces a wealth of tactics to exploit and be wary of.

Often, what becomes important in Leiserchess is the *threat* of zapping rather than the actual act of zapping. As a result, the actual area that your Monarchs' lasers cover may not be too important. What is beneficial is the area that *could* be covered if you combine a move action with a Monarch zap. Similarly, the threats of shoving,

squashing, and ejecting can sometimes be more important than their actual occurrence.

**Strategy.** Strategy is required for a player with a dominant position to prevail over an opponent. Without a thoughtful plan, the dominant player may not be able to engineer a zap. Although Leiserchess is a young game, some strategic elements have begun to emerge from games played thus far:

- Try to keep some Pawns near your Monarchs. An isolated Monarch is generally easier to zap than one with bodyguards. Also, try to move some Pawns near the enemy Monarch, but watch out not to let your opponent use your own Pawns against you!
- Keep Pawns active and ensure that they have high qi. A Pawn with low qi is nearer the edge of the board and risks being ejected by a higher-qi enemy Pawn.
- Try not to let your Pawns get too close to your opponent's Pawns if the opponent's Pawns have higher qi. You don't want to be pushed around.
- In the endgame, obtain a central position for your Monarch relative to your opponent's Monarch. After most of the Pawns are eliminated, a centralized Monarch can more easily chase down and zap an edge-lurking opponent.
- Limit the mobility of your opponent's Monarchs by threatening to attack adjacent squares. That is, make yourself ready to attack the enemy Monarchs should they move, thereby limiting their mobility.

## Recording Board Positions

Board positions can be recorded using a modified [Forsyth-Edwards notation \(FEN\)](#). For example, the opening position can be described with the following FEN string:

```
nn6nn/sesw1sesw1sesw/8/8/8/8/NENW1NENW1NENW/SS6SS W
```

The FEN string is always composed from Tangerine's point of view. To create a FEN string for a position, consider the pieces rank by rank, starting with rank 7 and ending with rank 0. Within each rank, the FEN string describes the contents of each square from a to h as follows. Each piece is encoded by a two-letter sequence describing which way it is facing, where upper case letters stand for Tangerine, and lower-case letters stand for Lavender.

Specifically, the Tangerine Monarch is encoded as **NN**, **EE**, **SS**, and **WW**, depending on whether it is facing north (toward the higher-numbered ranks), east (toward higher-lettered files), south, or west, respectively. The Lavender Monarch is similar, but using lower-case letters: **nn**, **ee**, **ss**, and **ww**. A Tangerine Pawn is encoded using upper case as **NE**, **SE**, **SW**, and **NW**, depending on whether its mirror is facing northeast, southeast, southwest, or northwest, respectively. Similarly, a Lavender Pawn is encoded using

lower case as **ne**, **se**, **sw**, and **nw**. The numbers **1** through **8** indicate consecutive empty squares, and a forward slash separates ranks. After the board description, either the letter **W** or **B** (for White and Black, the traditional chess colors) follows, depending on whether Tangerine (**W**) or Lavender (**B**) has the next move.

**Exercise:** Write a FEN string for the first position in the Tactics section.

## Recording Games

Games can be recorded using the following simple **algebraic notation**:

- If a piece is rotated, write down the square containing the piece followed by
  - **L** for a counterclockwise rotation — e.g., **g2L**;
  - **R** for a clockwise rotation— e.g., **g2R**;
  - **U** for a 180° rotation — e.g., **g2U**.
- If a piece is moved to an adjacent square, write down the source square followed by the destination square — e.g., **h3g4**.
- To record the null move, move the Monarch to its own square — e.g., **a2a2**. (Remember that a null move is illegal unless something is zapped.)
- Record the outcome of the game as **1-0** (Tangerine wins), **0-1** (Lavender wins), or **1/2-1/2** (draw).

Here's an example of a recorded game:

1. <b>a0b1 a7L</b>	16. <b>h2g3 f1f2</b>
2. <b>a1U a6b5</b>	17. <b>f0g0 d6c6</b>
3. <b>h0g1 a7L</b>	18. <b>g3f4 f2g2</b>
4. <b>c2b2 h7R</b>	19. <b>g0h0 g6R</b>
5. <b>h1R b5L</b>	20. <b>h0g0 g2g1</b>
6. <b>f2U a7b6</b>	21. <b>b2L b4b3</b>
7. <b>e1f1 b5b4</b>	22. <b>c2b3 a4b4</b>
8. <b>f2R h6g5</b>	23. <b>b3b4 c5b4</b>
9. <b>f2g3 g5f4</b>	24. <b>b1U g1R</b>
10. <b>h1g2 f4g3</b>	25. <b>f4f5 e6e5</b>
11. <b>g1L h7g7</b>	26. <b>f5g4 g1f2</b>
12. <b>g1f0 g3f2</b>	27. <b>b2c1 b4c4</b>
13. <b>d1c2 f2f1</b>	28. <b>c1U c6b7</b>
14. <b>g2f1 e0e1</b>	29. <b>c1b0 g7U</b>
15. <b>f0U e1f1</b>	<b>0-1</b>

**Exercise:** Use algebraic notation to record the sequence of moves in the Tactics section.

**Exercise:** Play Leiserchess with a friend or a Leiserchess-playing program and record the moves. Then replay the game from your record.

## Feedback

Please email questions or comments to [leiserchess@mit.edu](mailto:leiserchess@mit.edu). Thank you, and we hope you enjoy Leiserchess 2023!