

# Magical Mathematics!

David Lipshutz

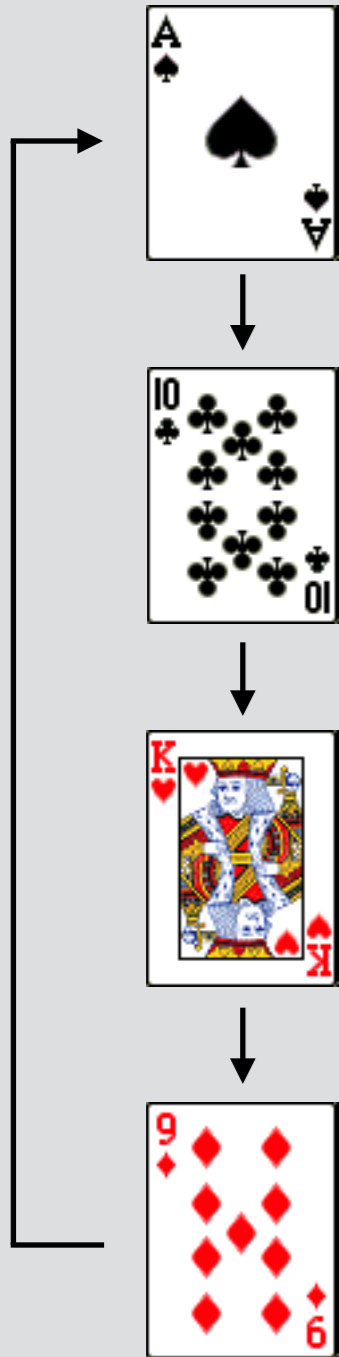
Vartan Gregorian Science Conference

June 11, 2014

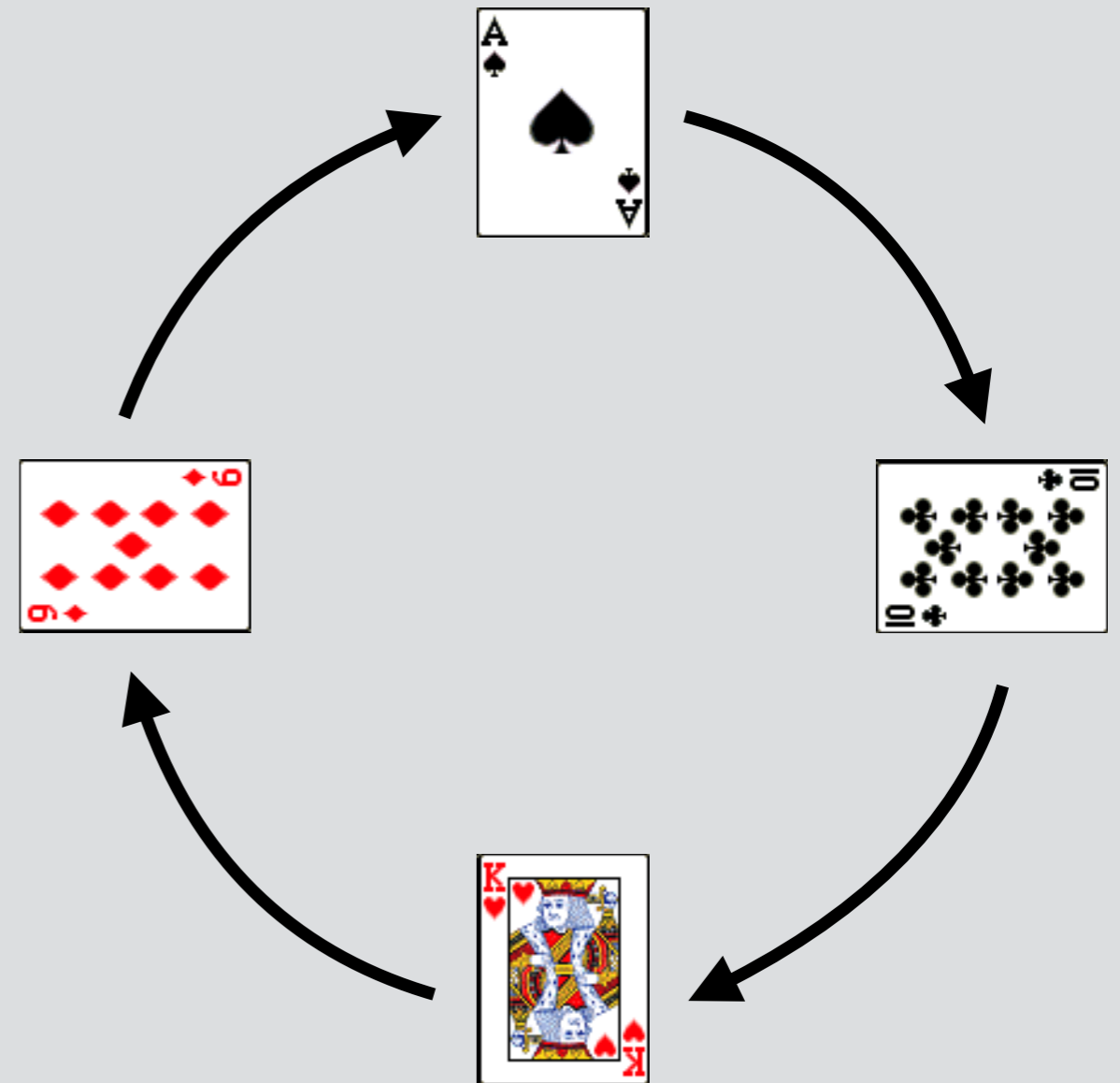
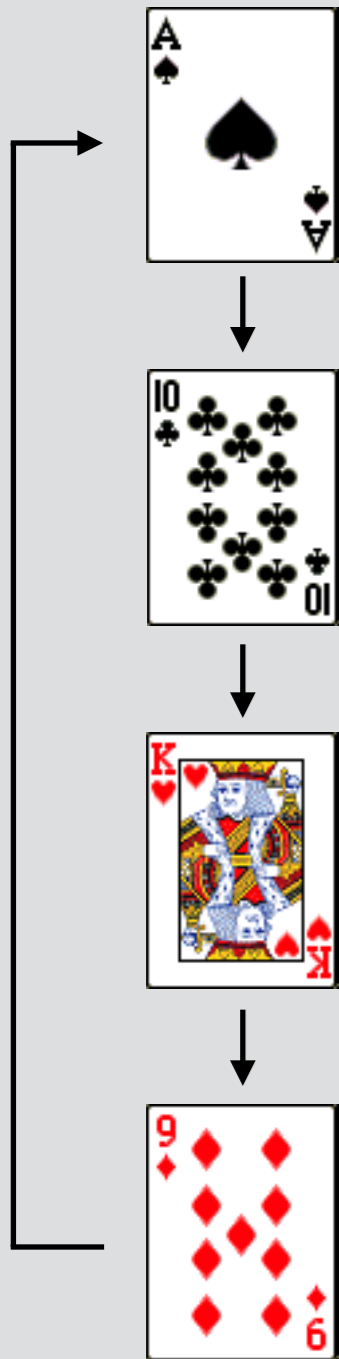
# Cutting the deck keeps the order



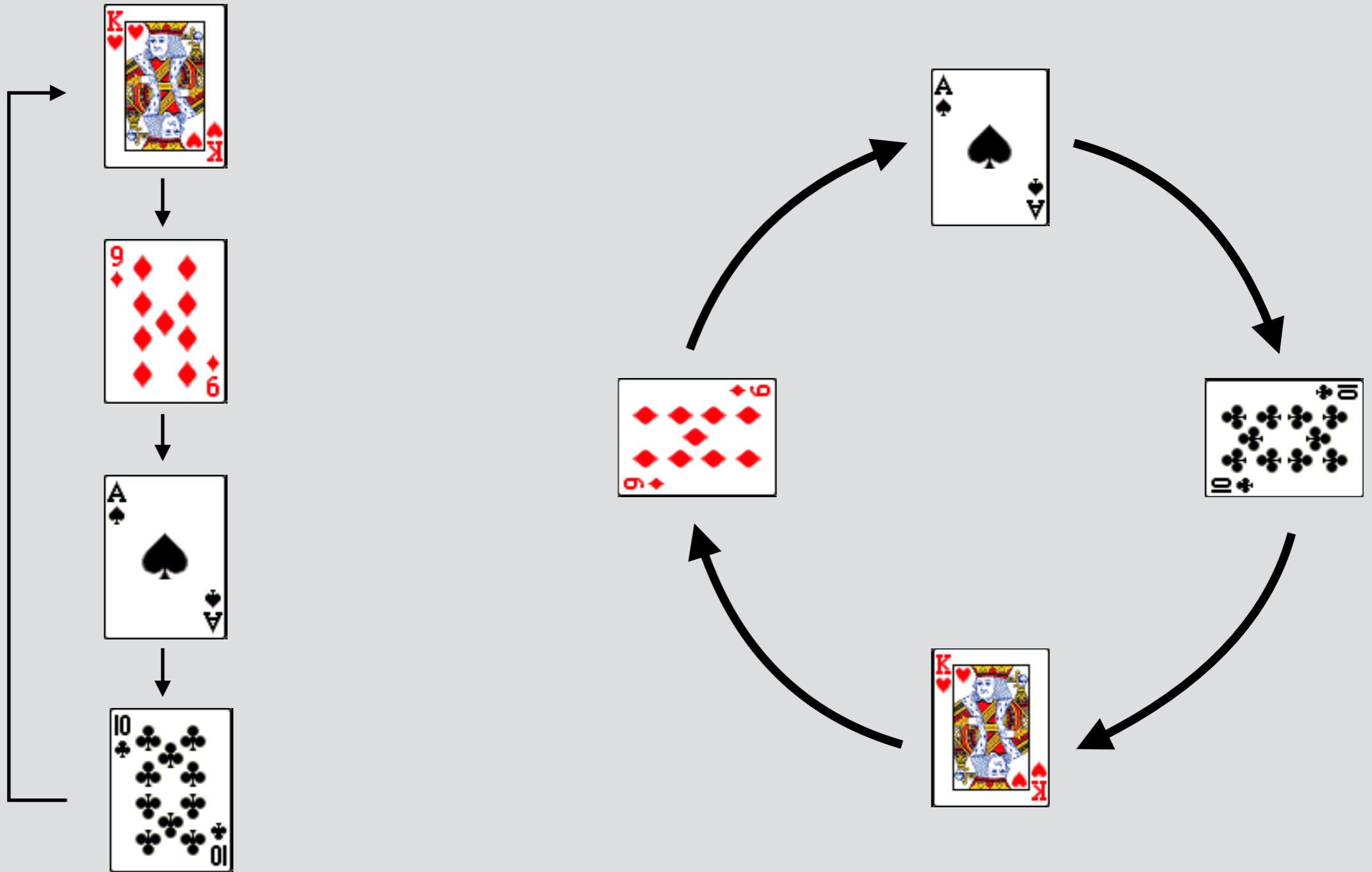
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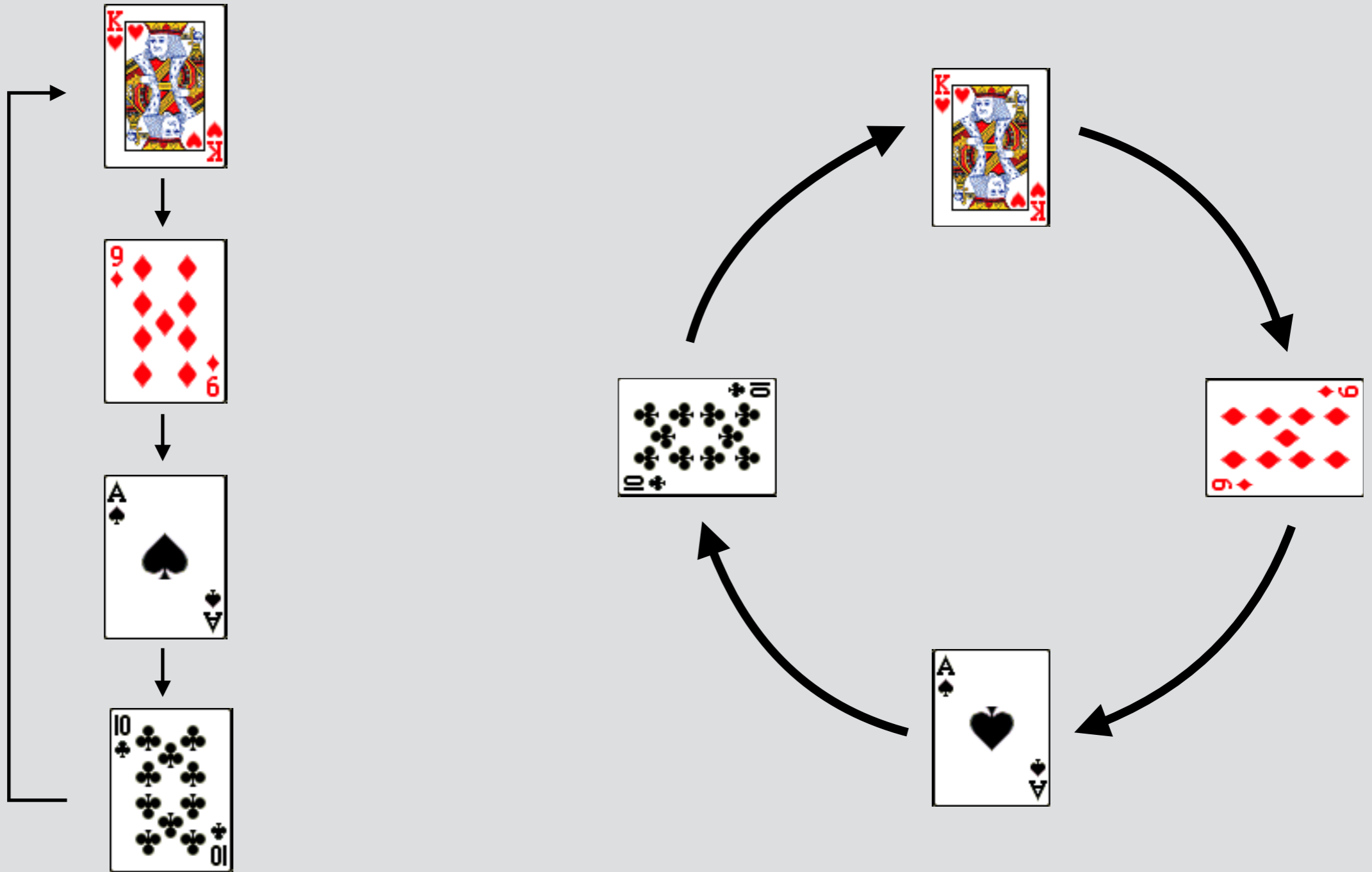
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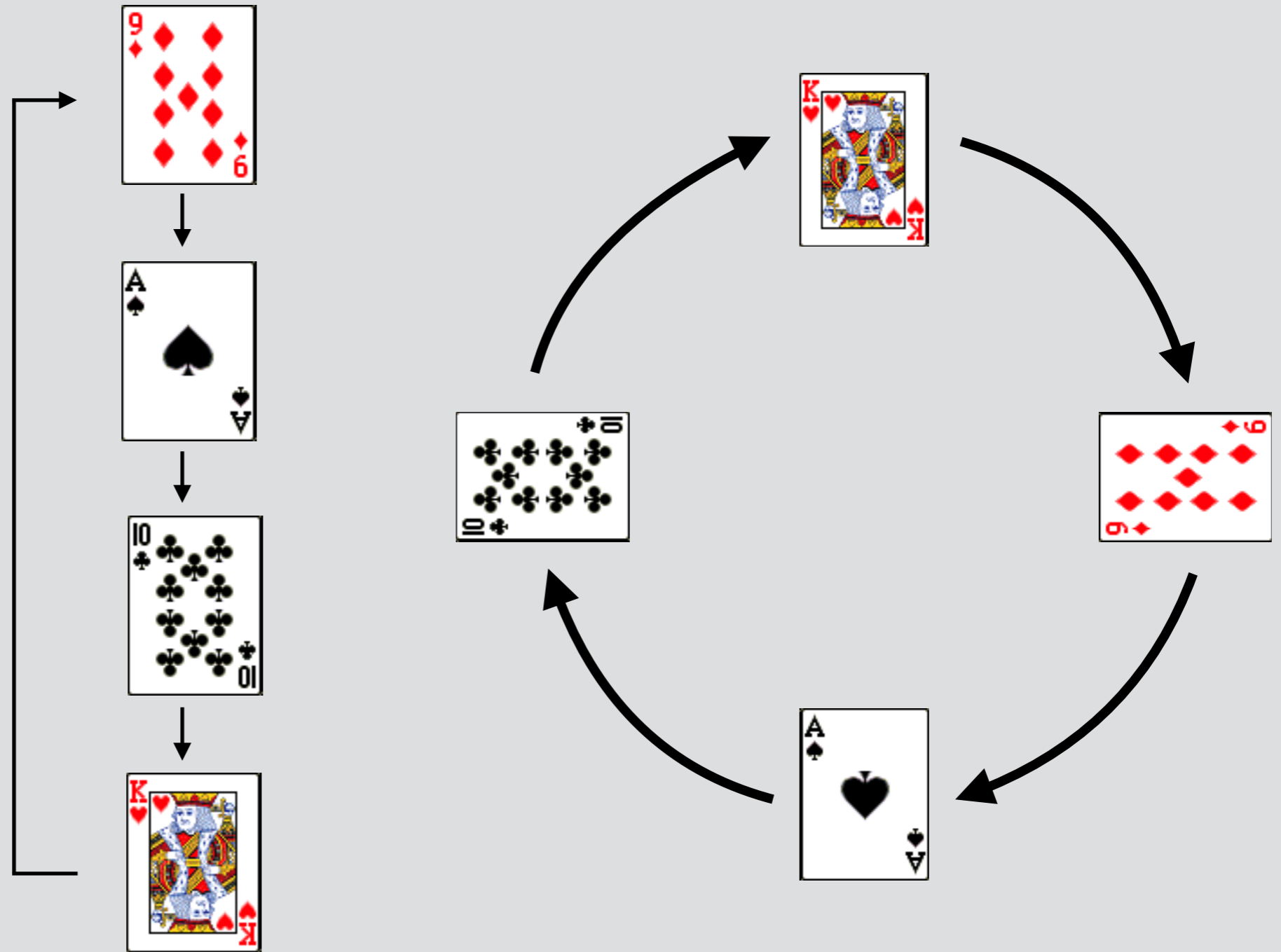
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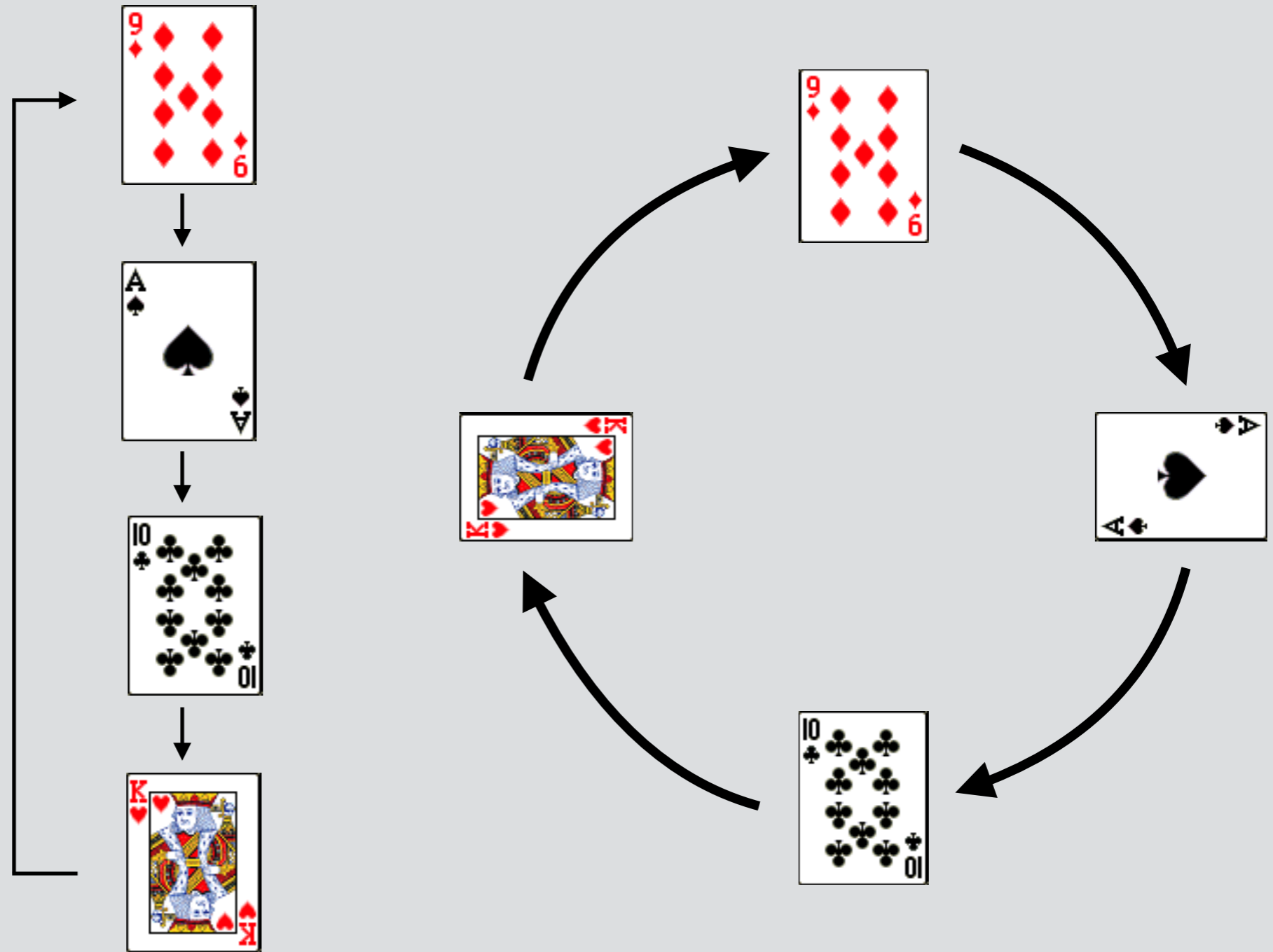
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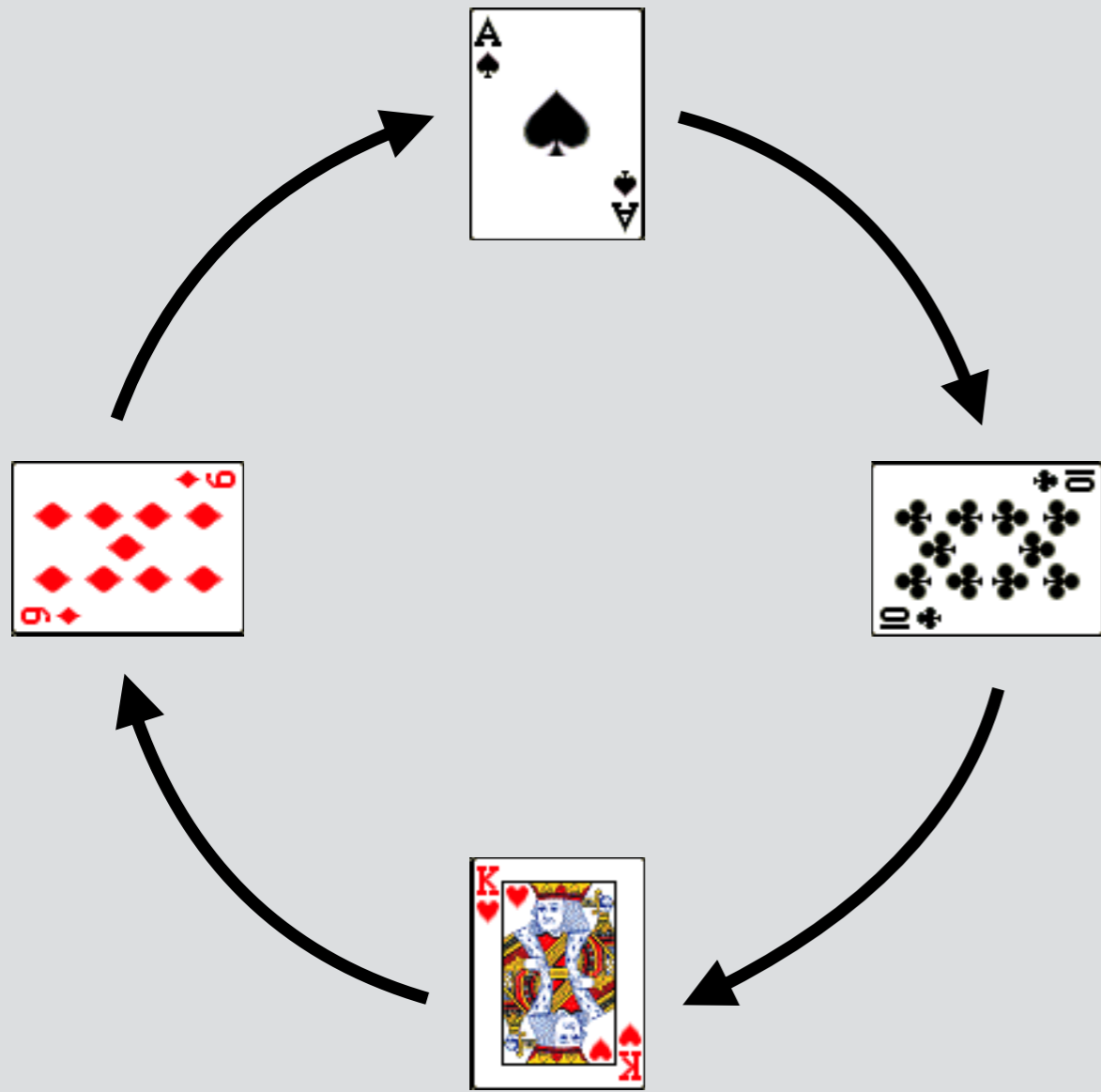
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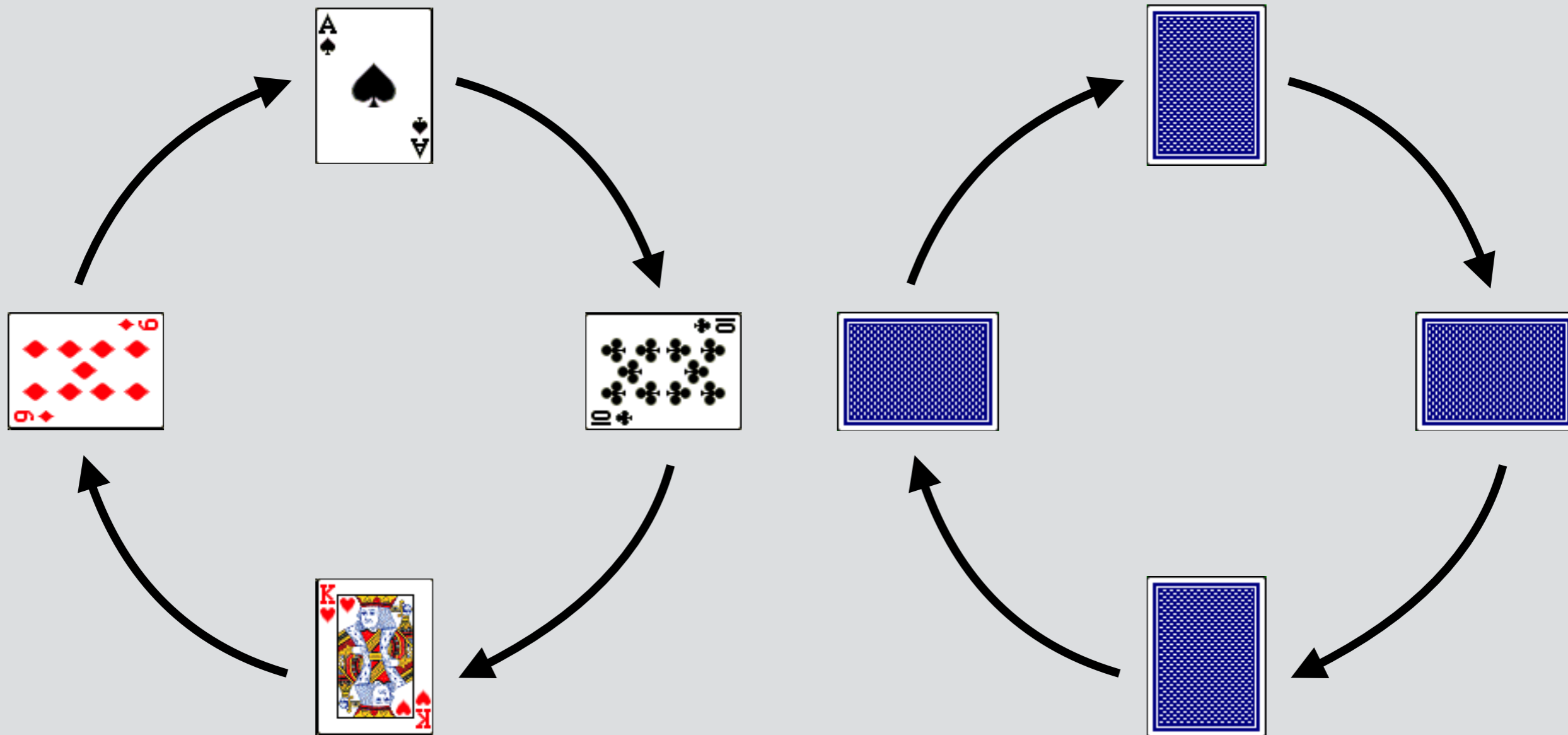


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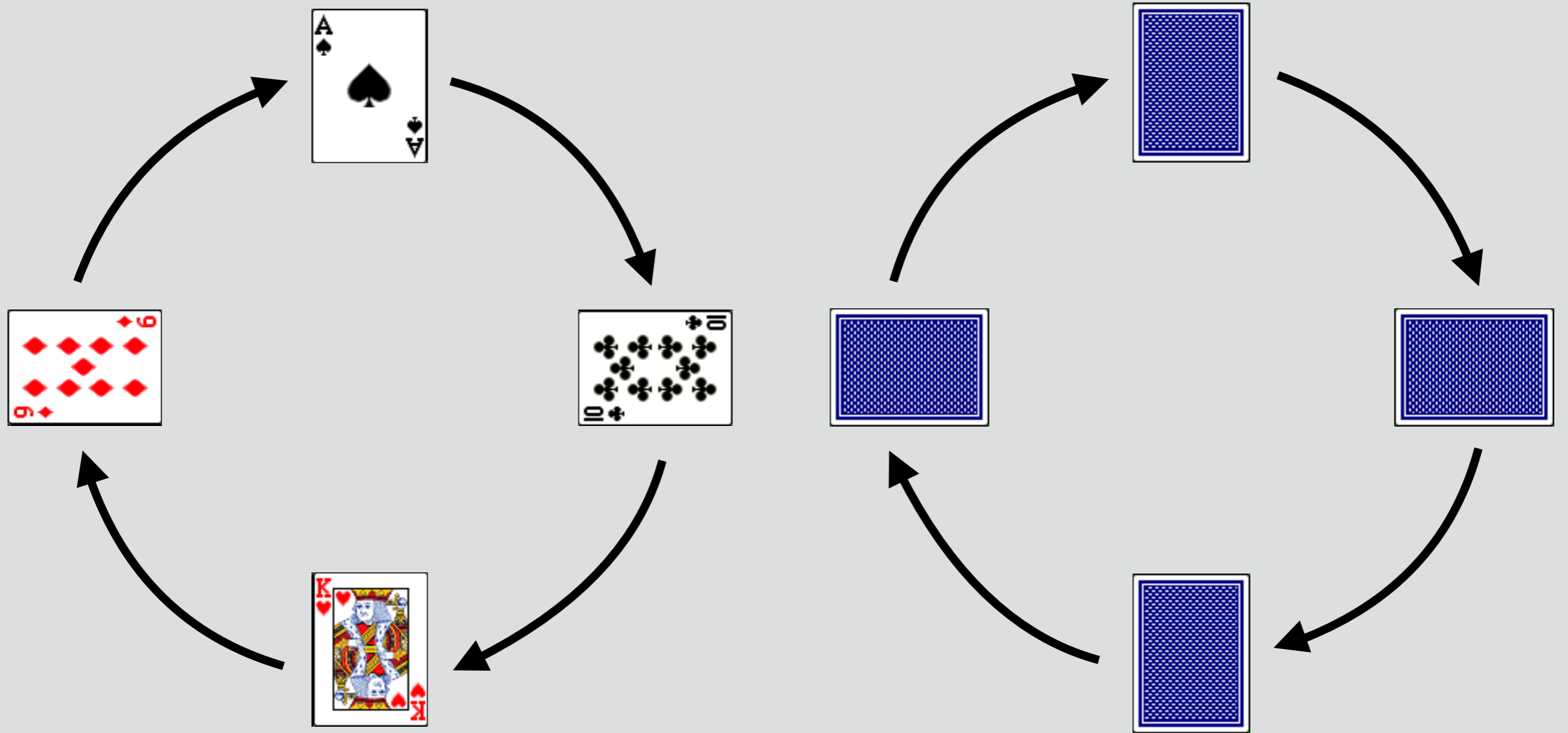




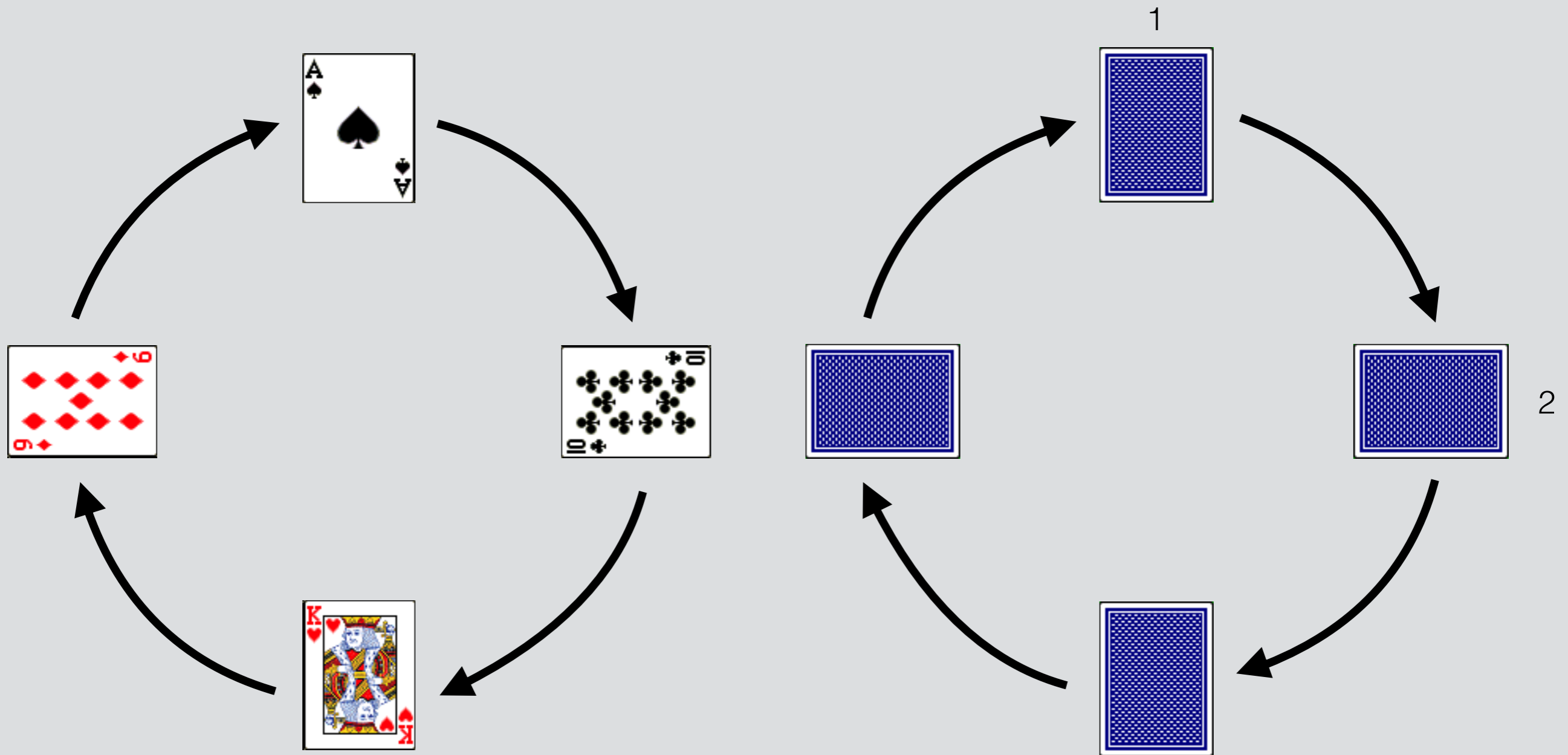




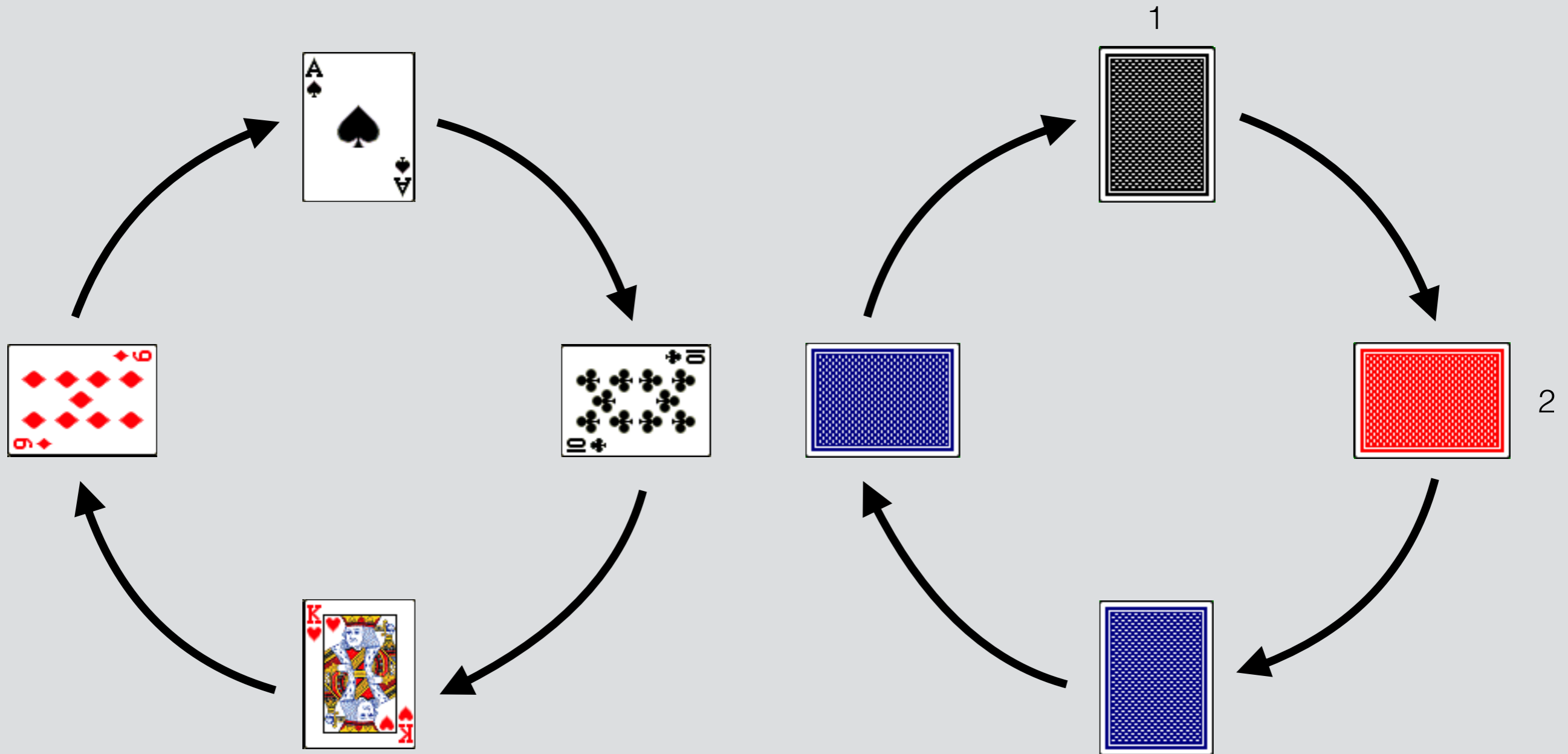
# Cut the deck



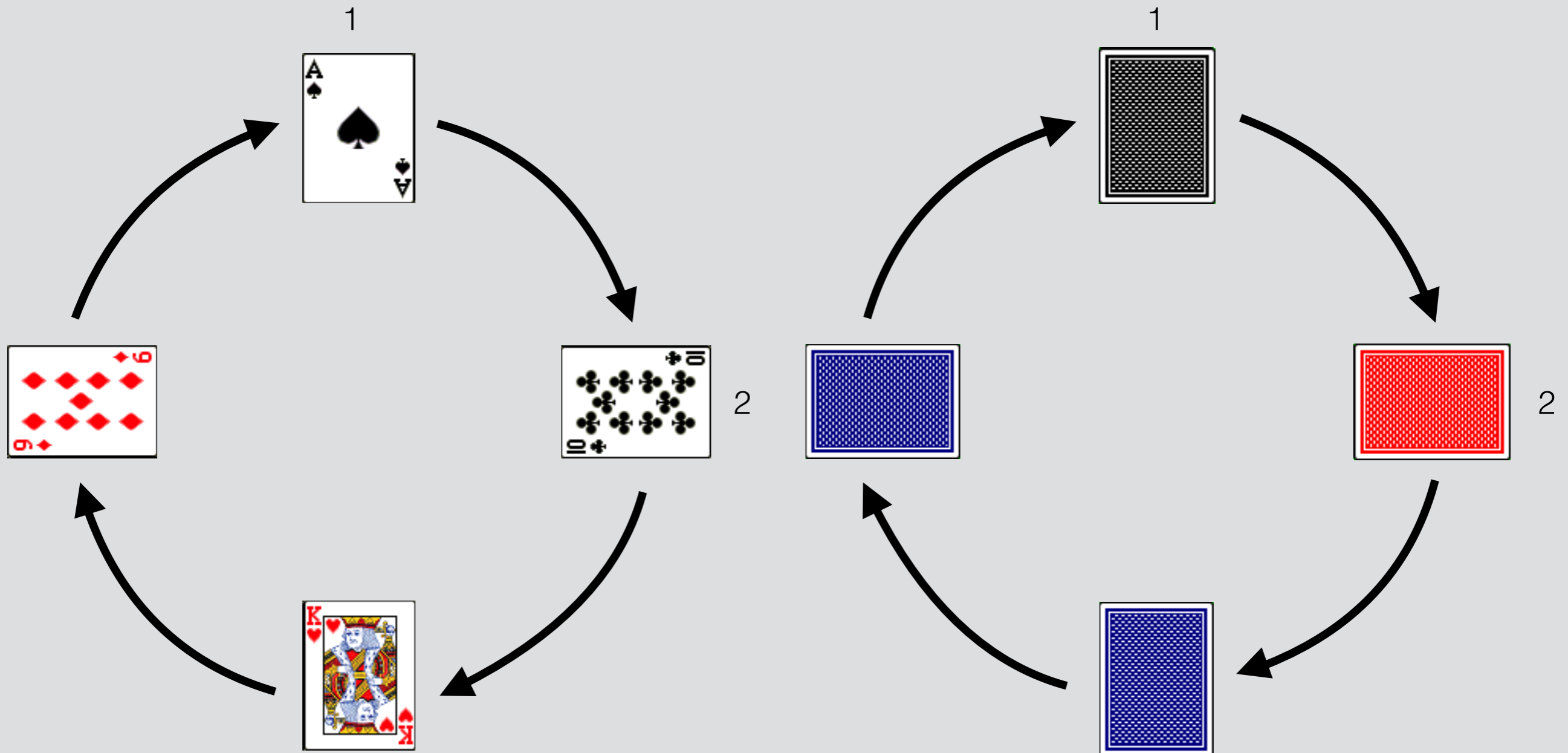
# Draw two cards



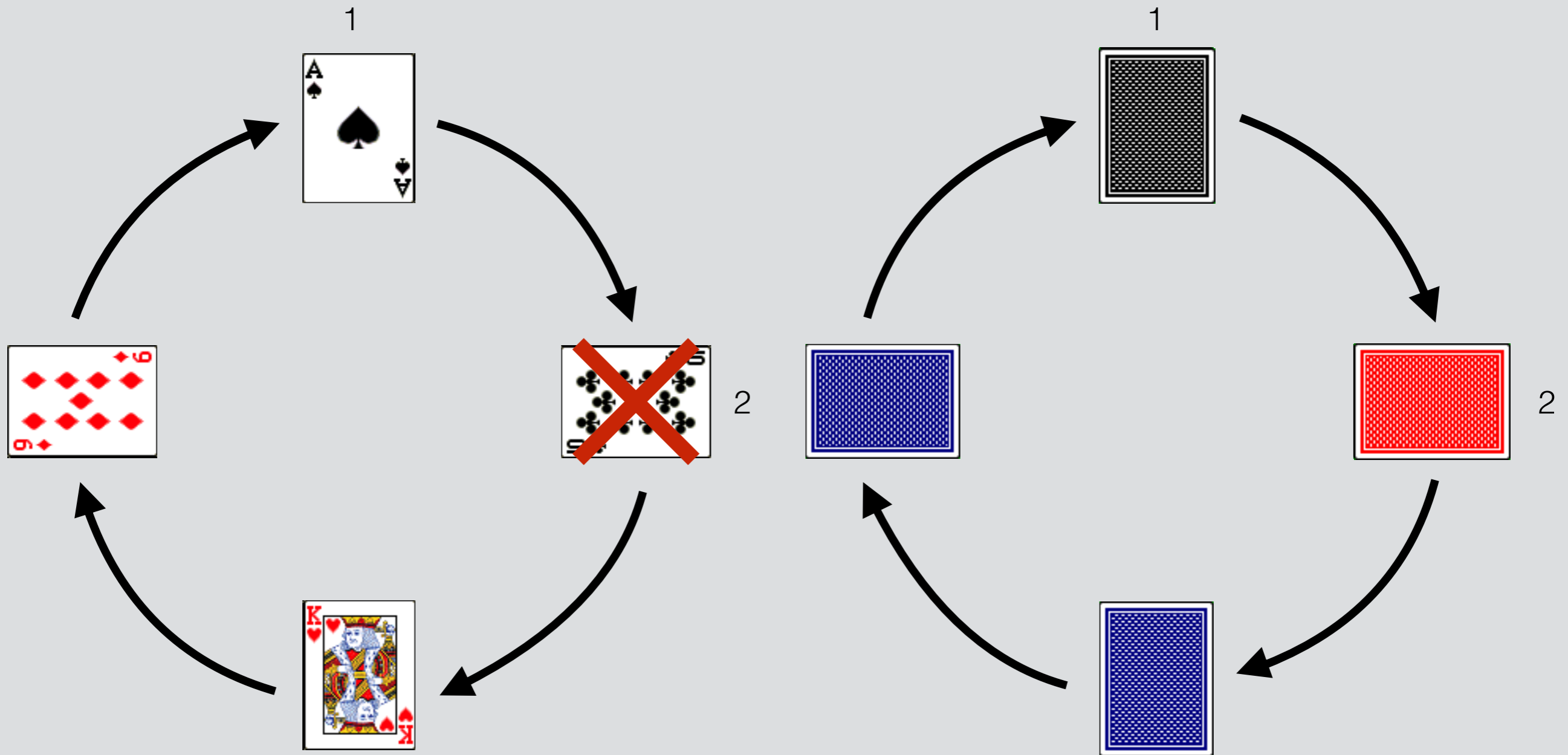
# Ask what color they are



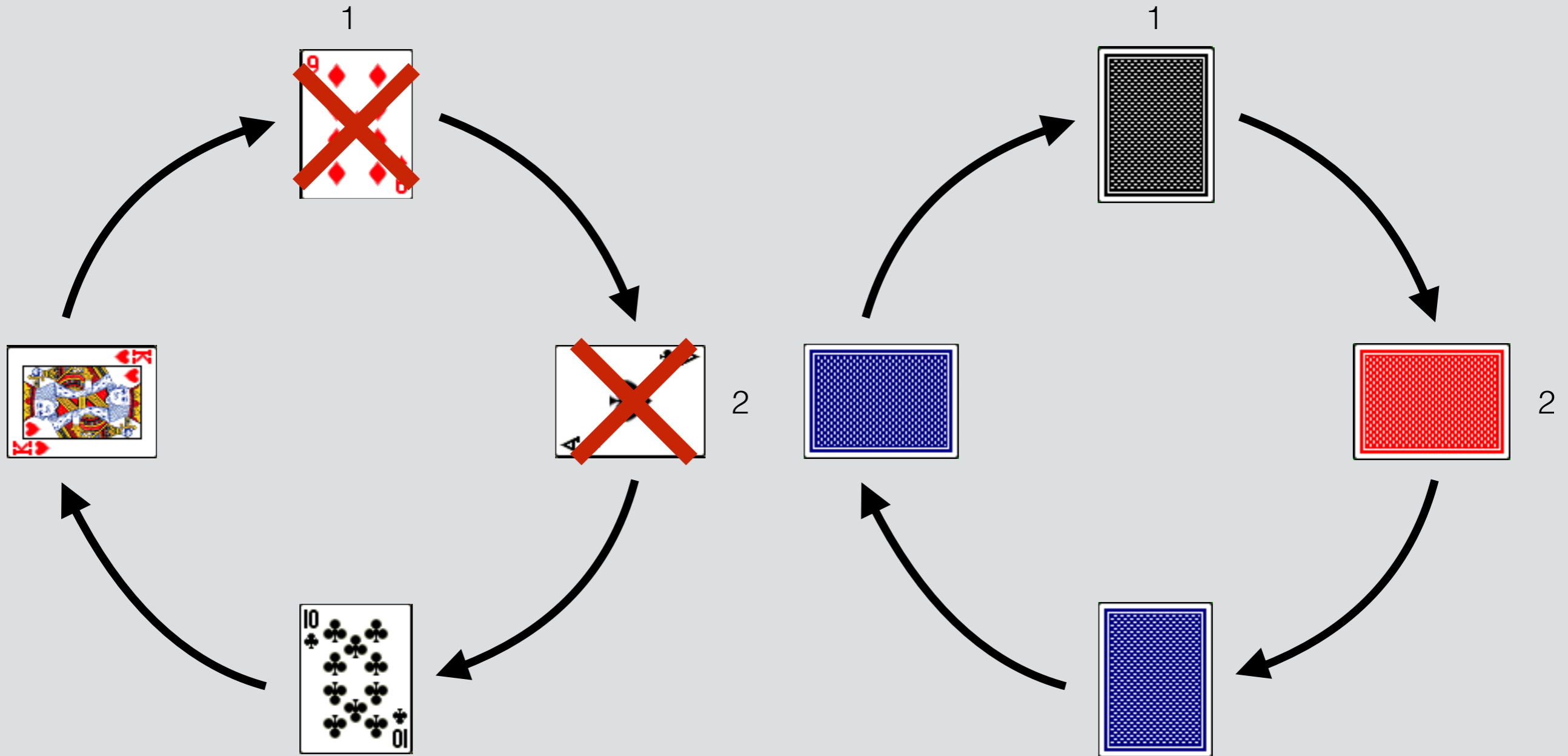
# Match the colors



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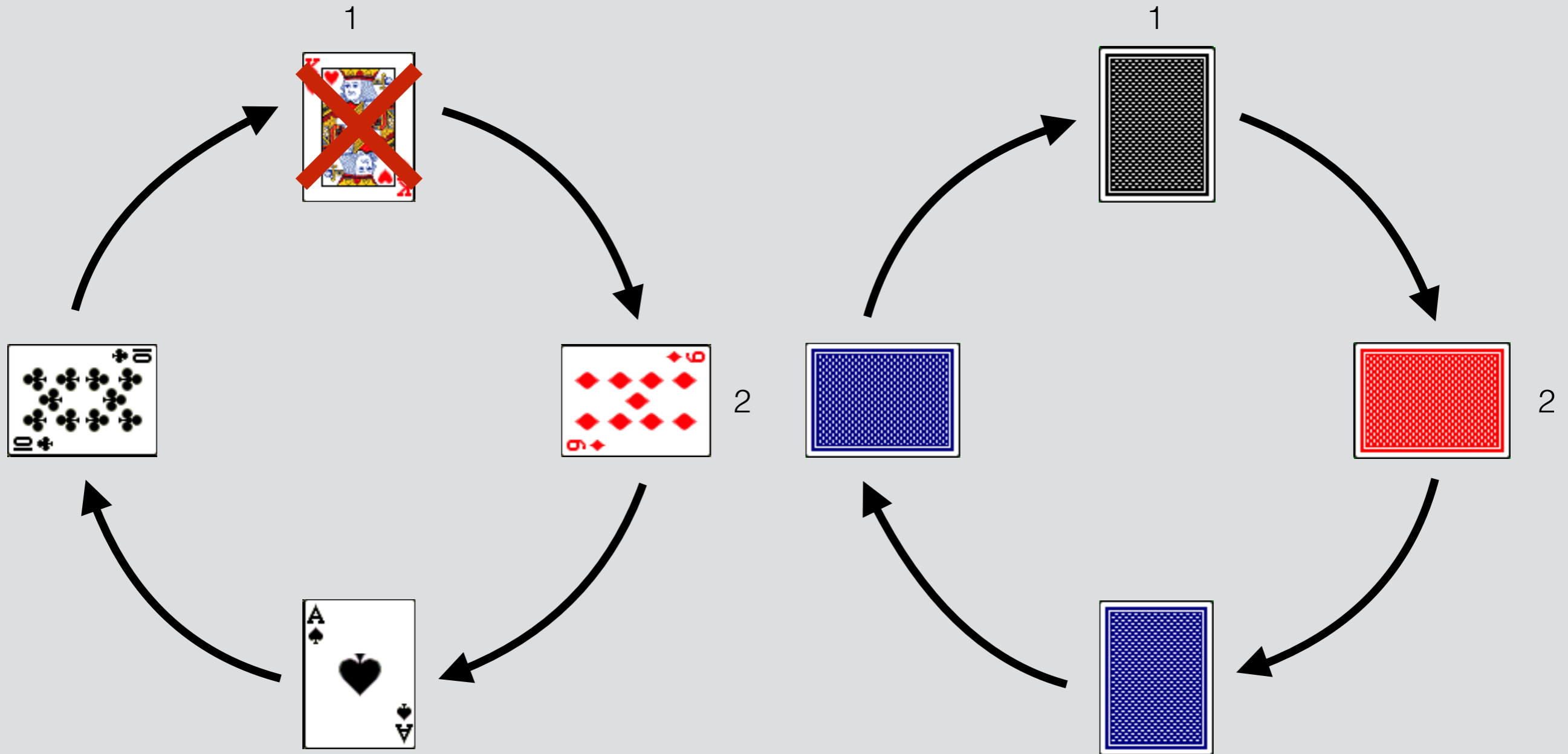


# Match the colors

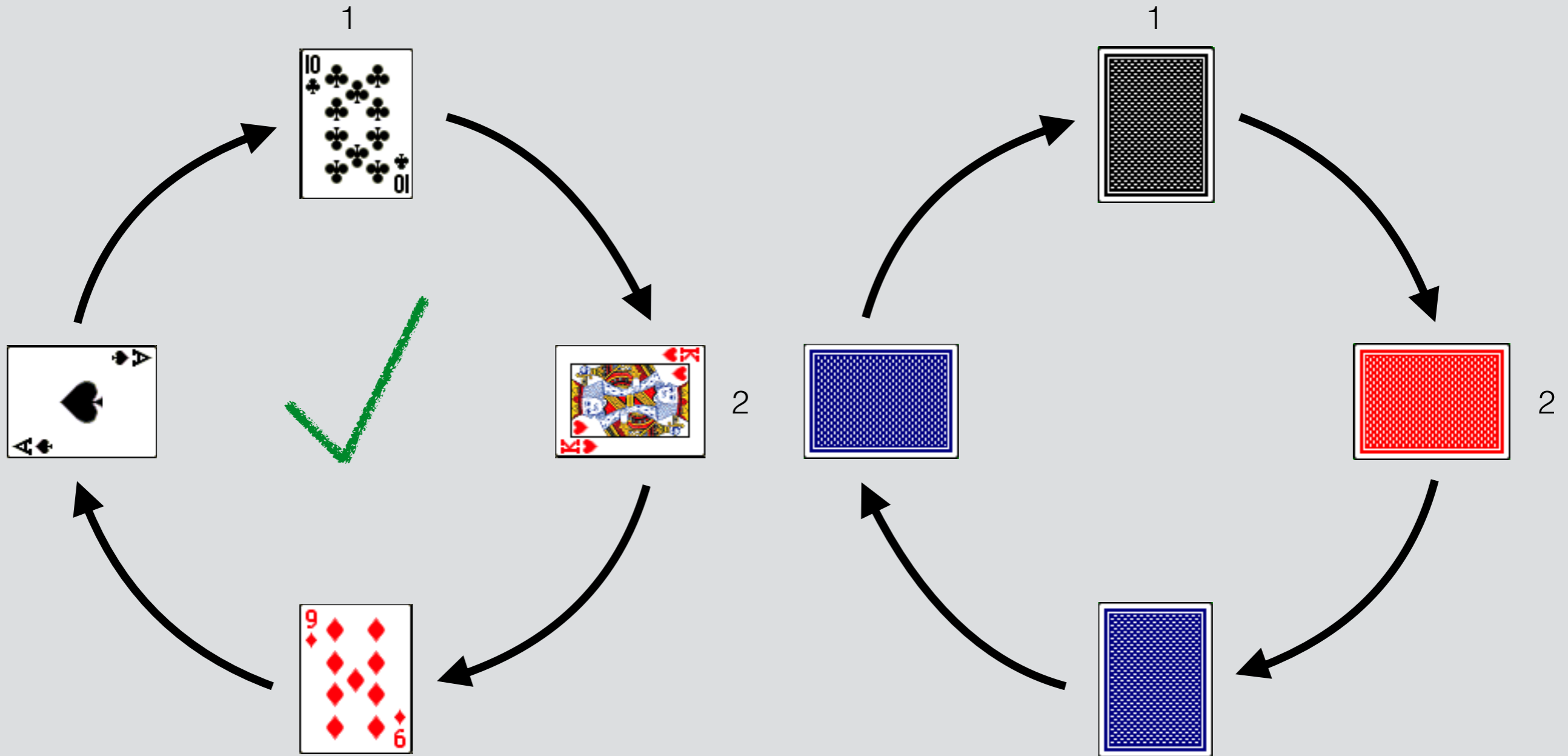




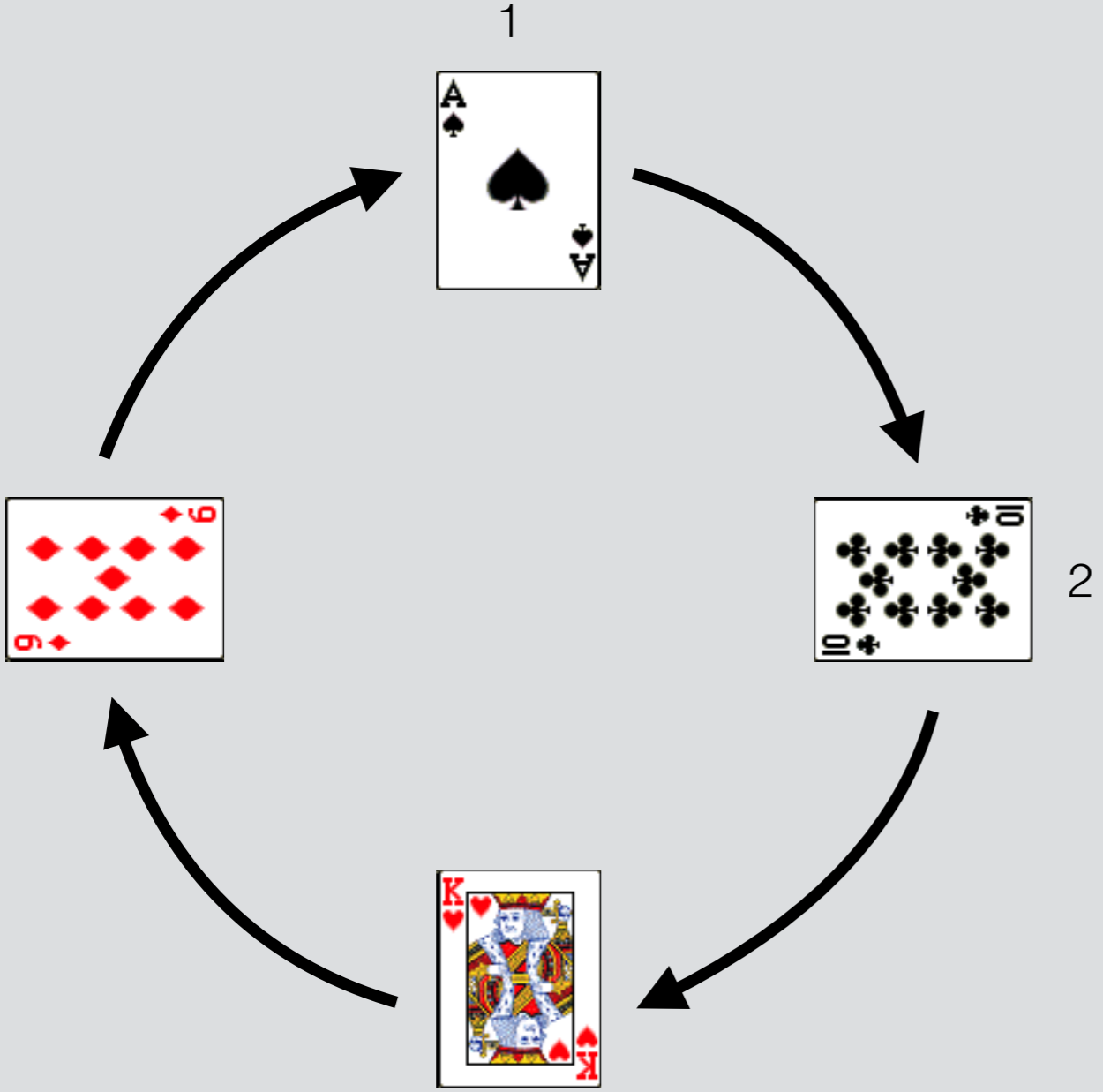
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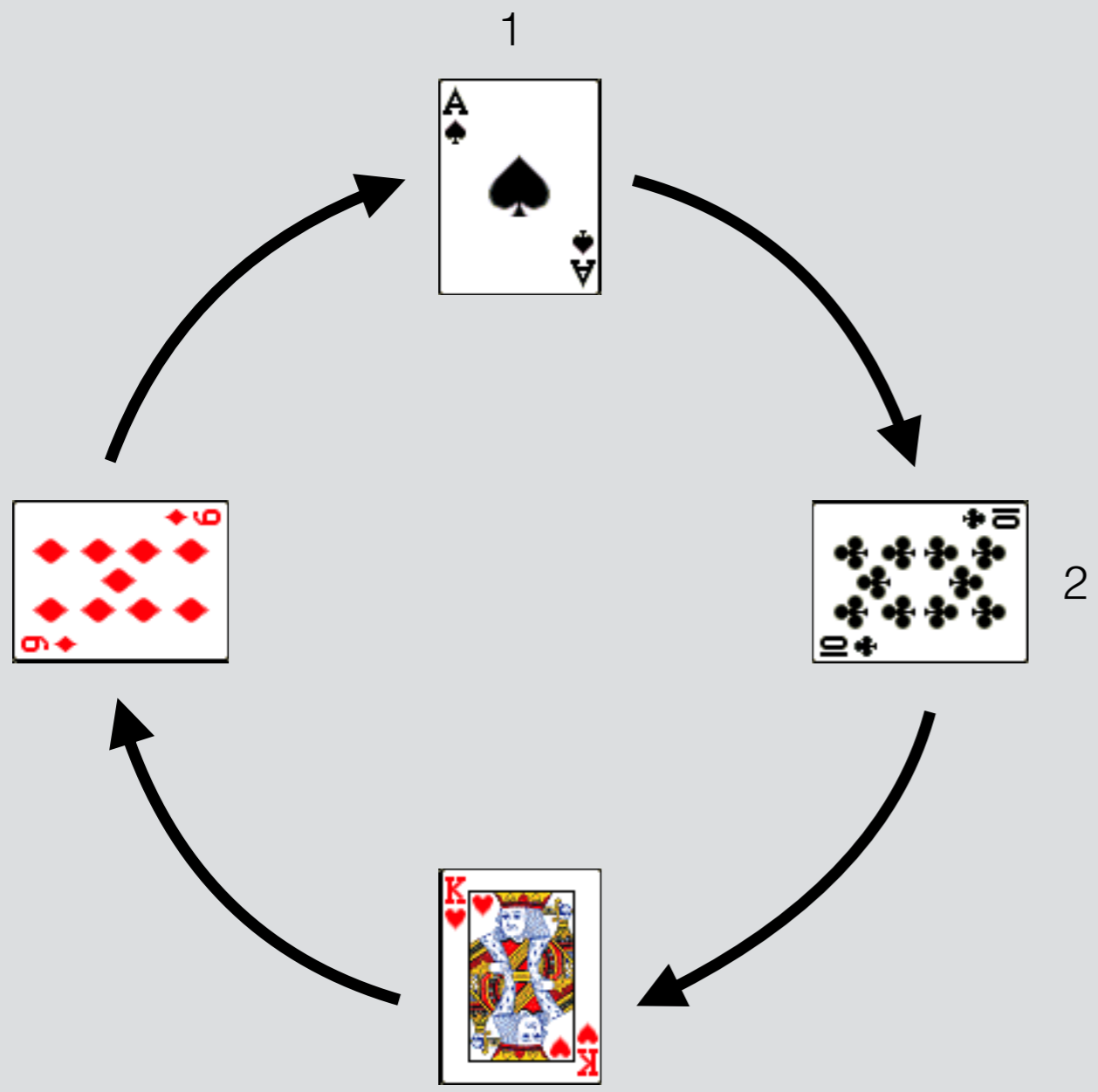


# Order is important!

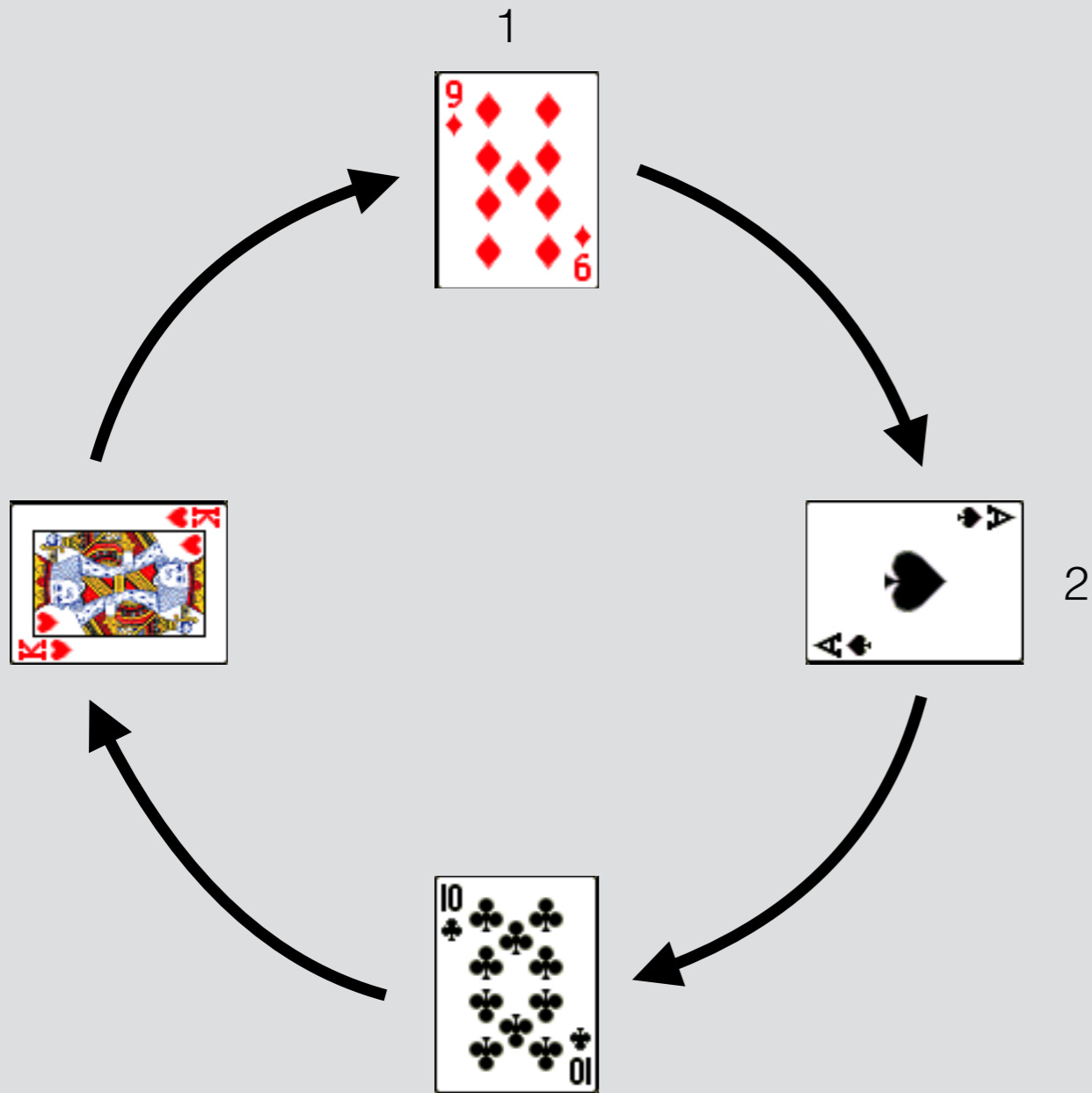


# Order is important!

## 1. Black Black

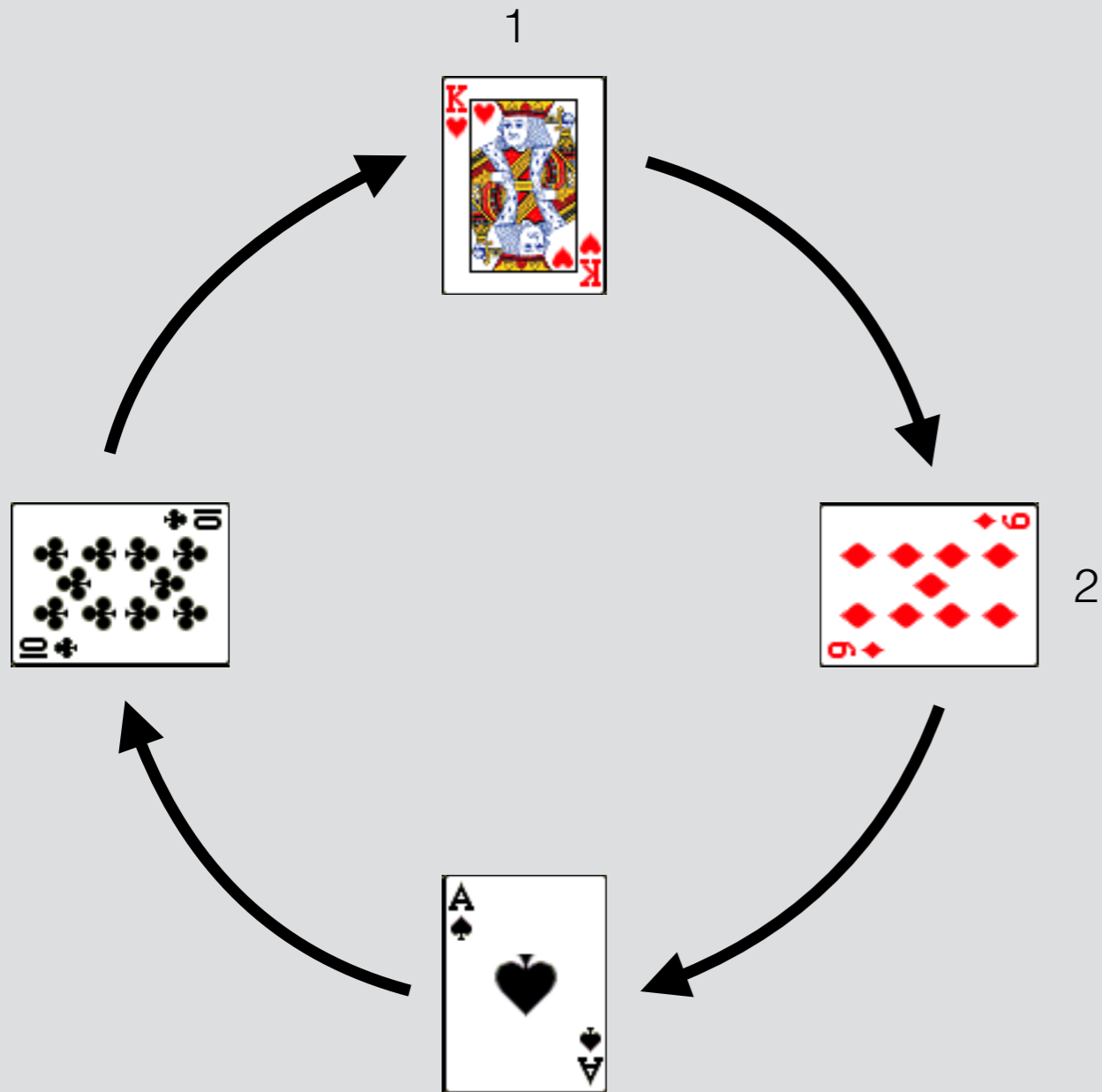


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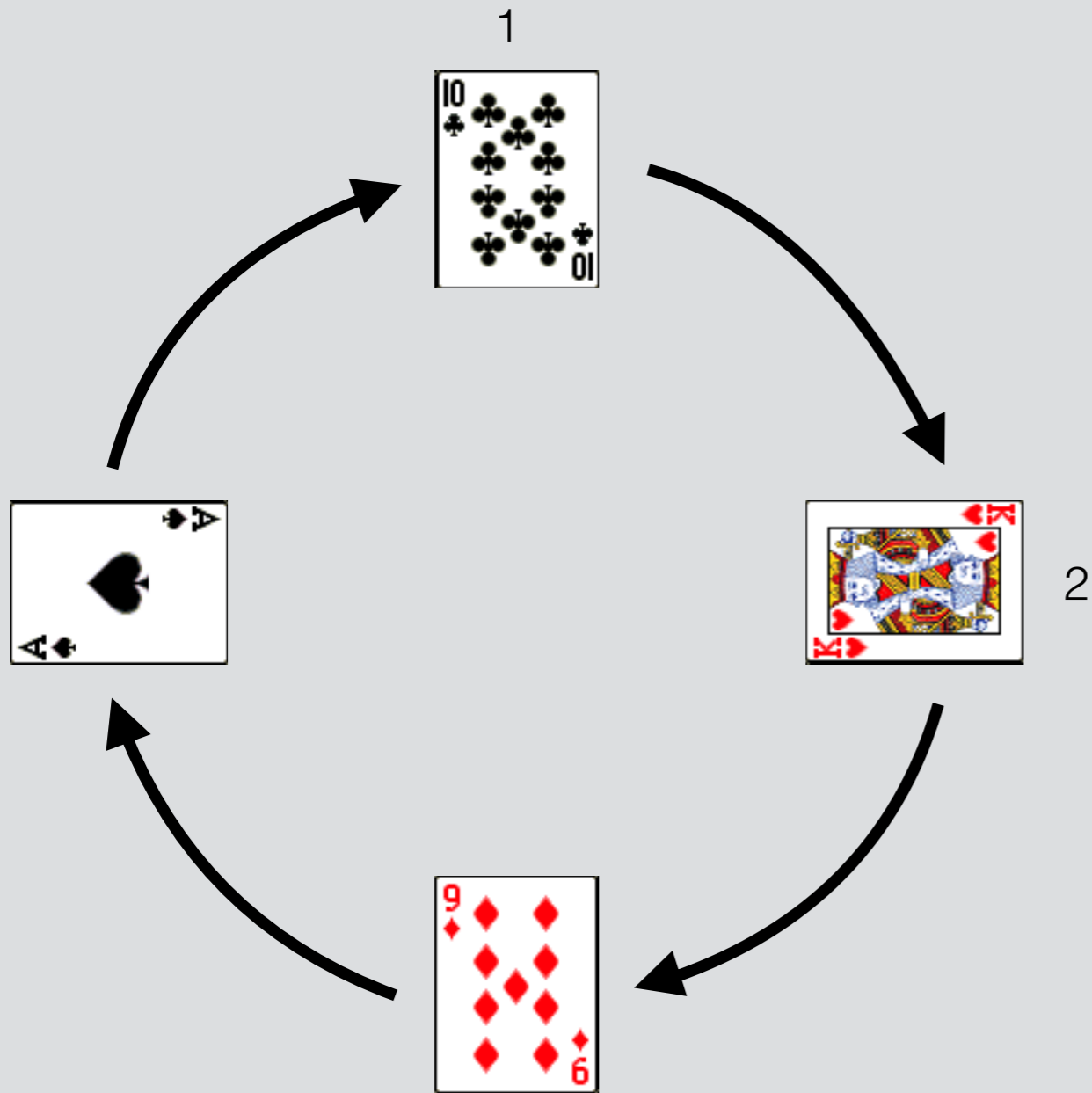
1. **Black Black**
2. **Red Black**

# Order is important!



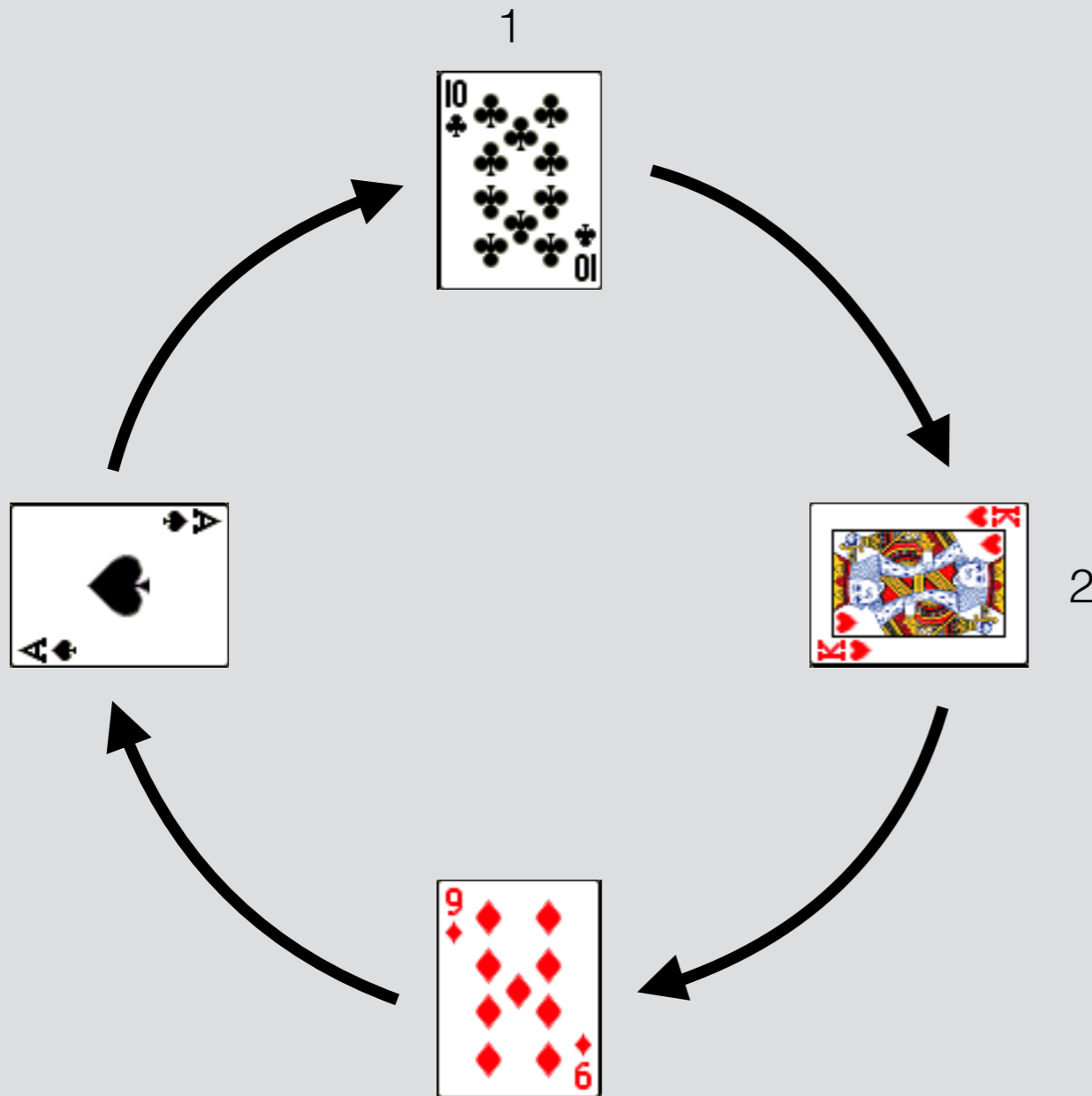
- 1. Black Black**
- 2. Red Black**
- 3. Red Red**

# Order is important!



1. **Black Black**
2. **Red Black**
3. **Red Red**
4. **Black Red**

# Order is important!

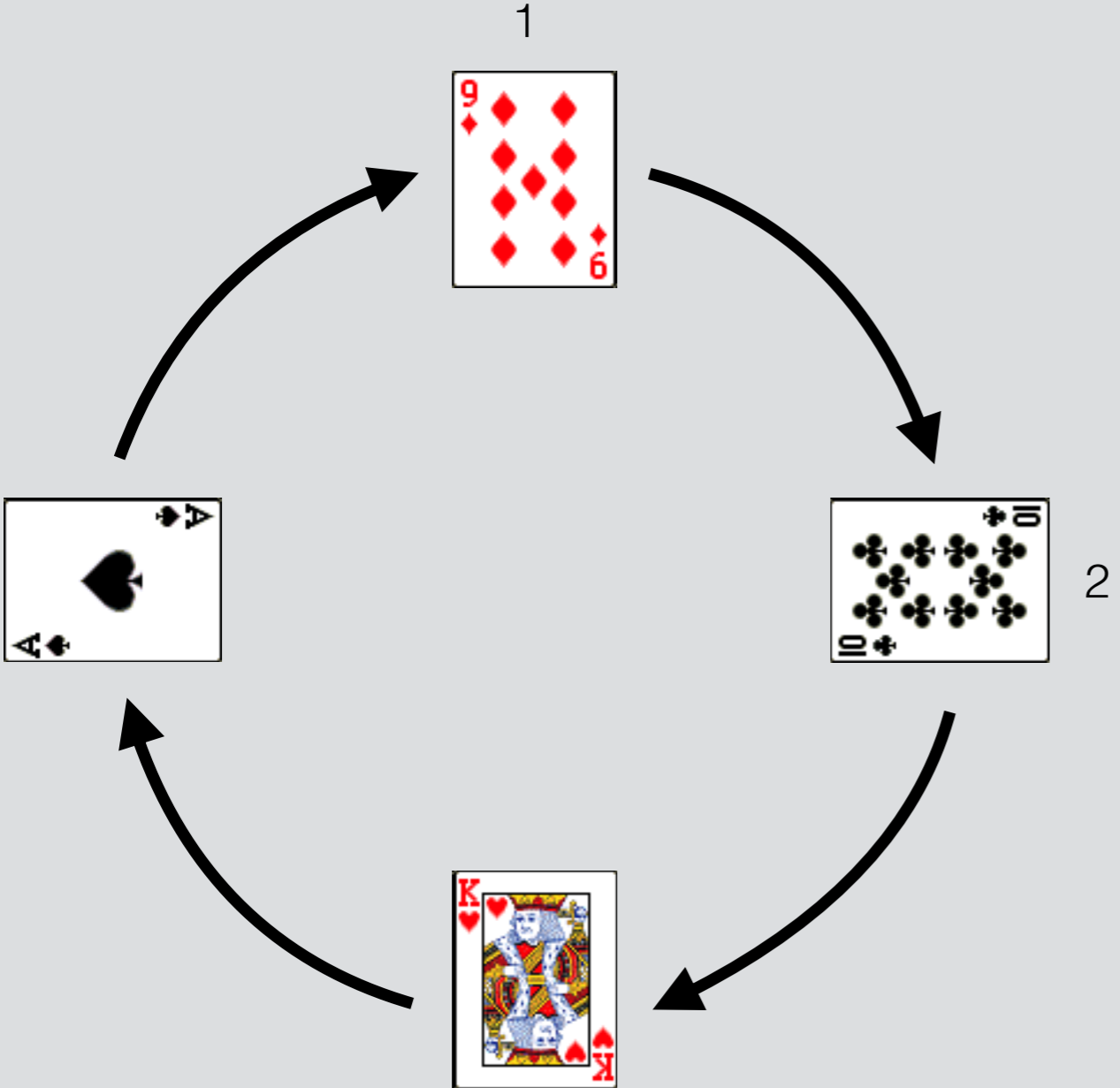


1. **Black Black**
2. **Red Black**
3. **Red Red**
4. **Black Red**

**Every combination only happens once!**

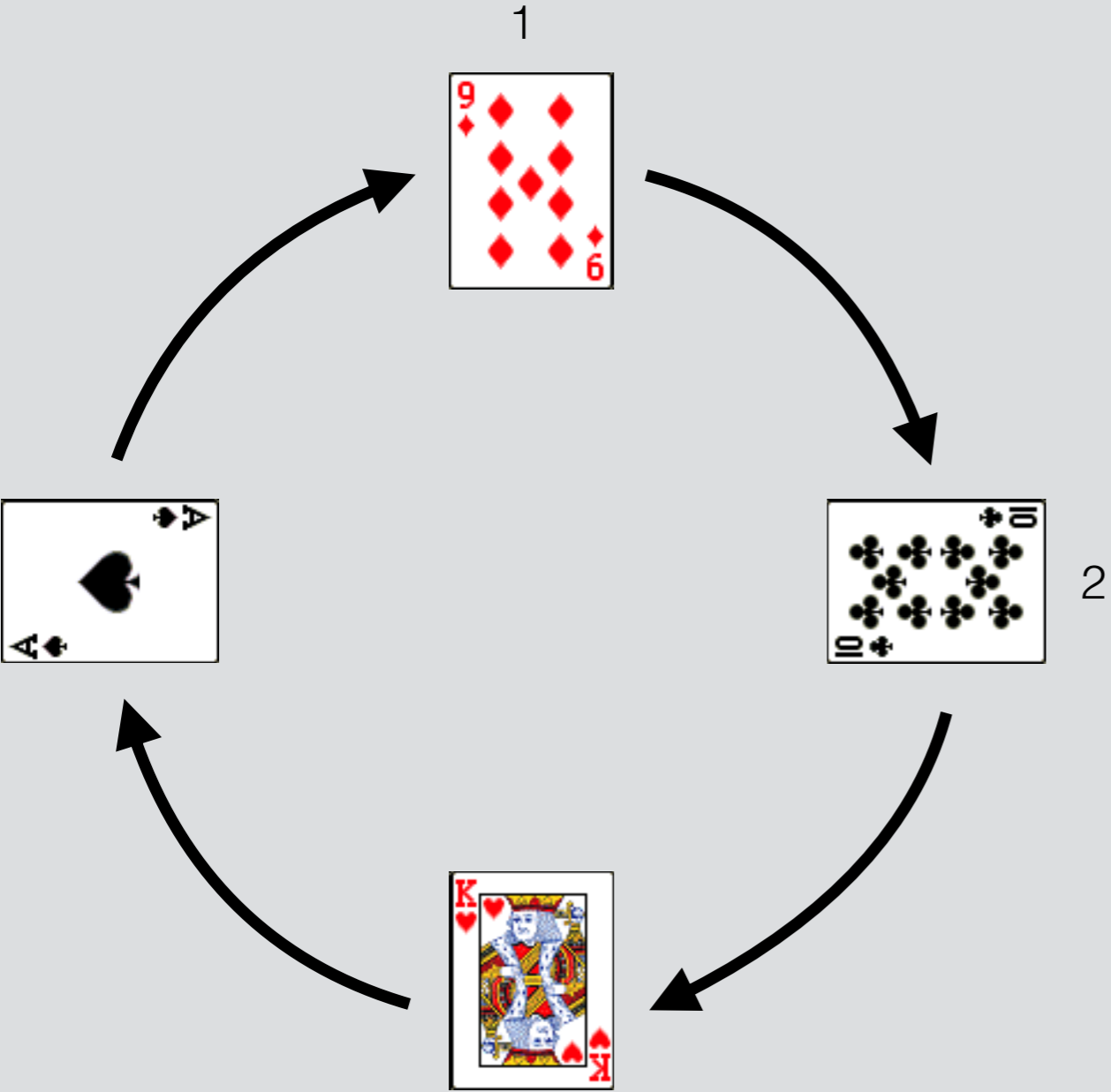


# Order is important!

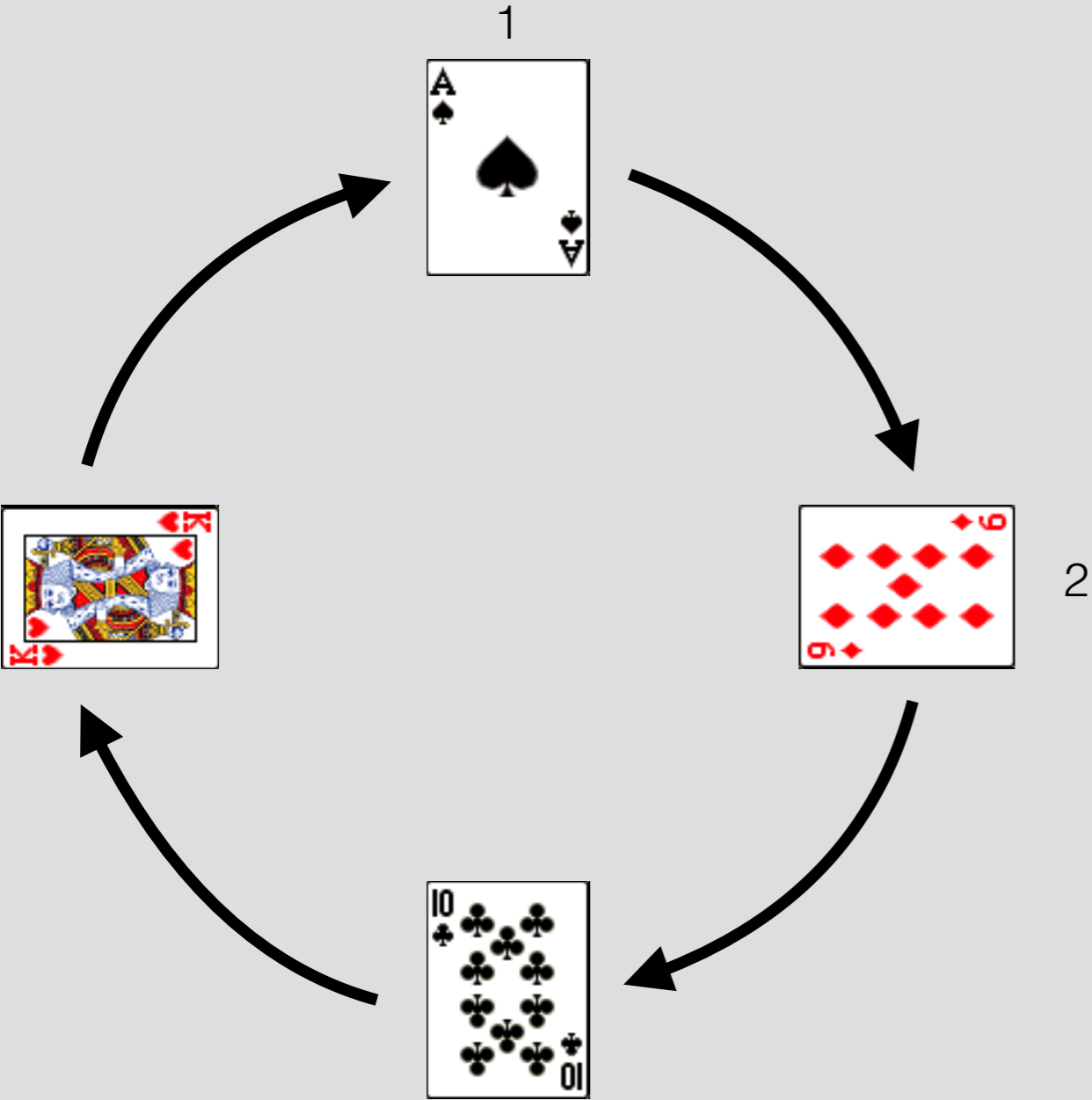


# Order is important!

## 1. **Red** **Black**

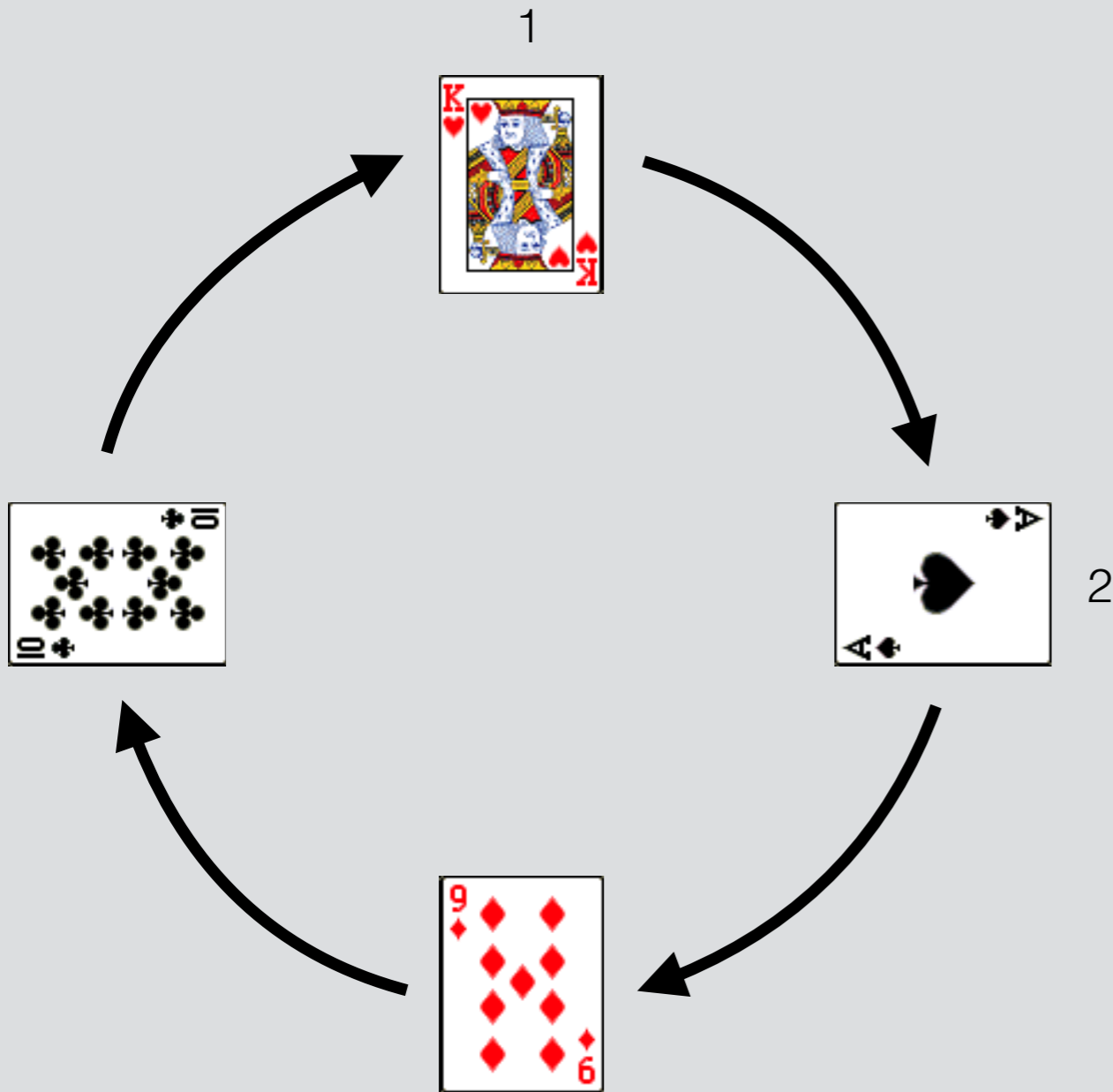


# Order is important!



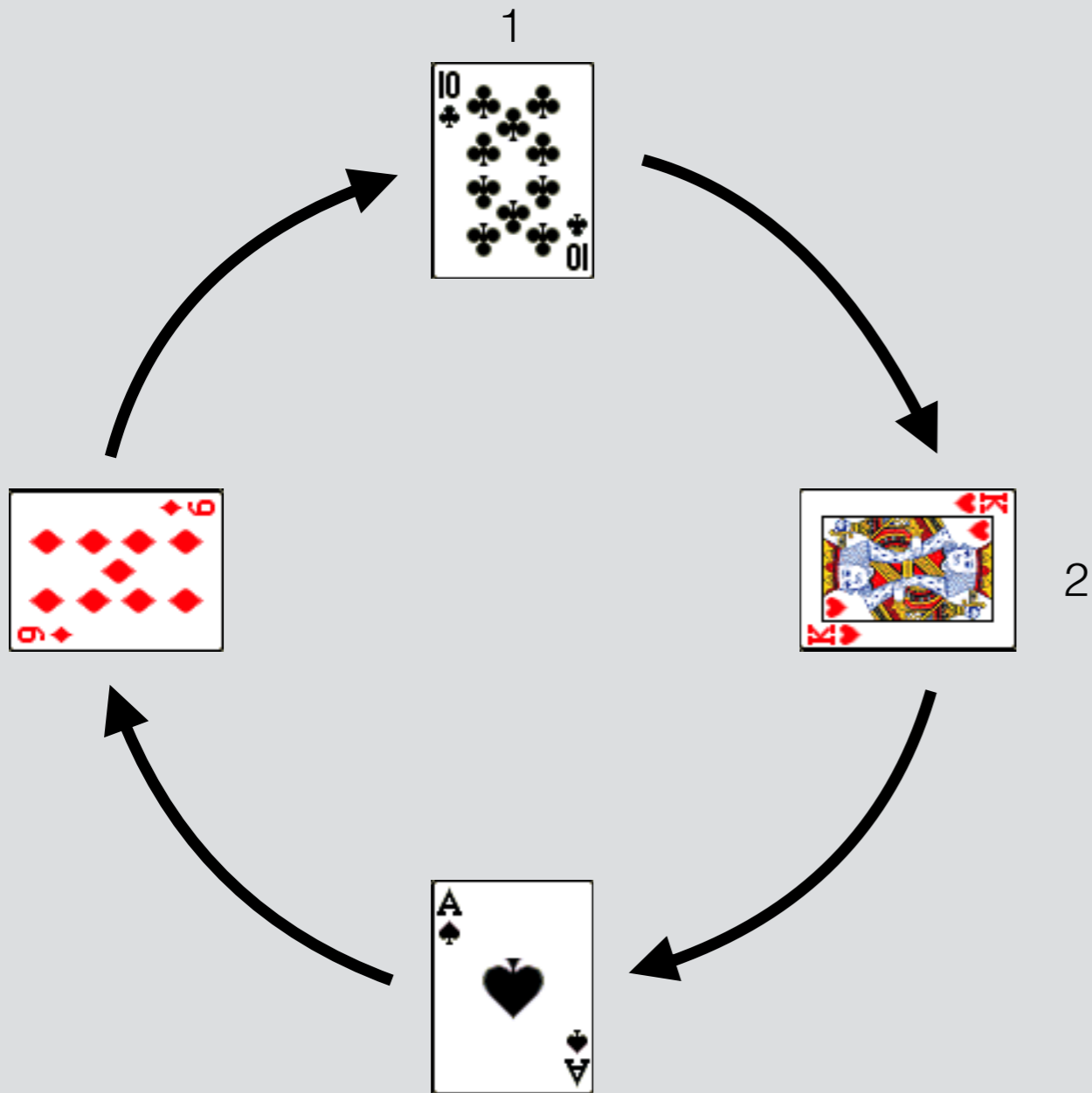
- 1. **Red Black**
- 2. **Black Red**

# Order is important!



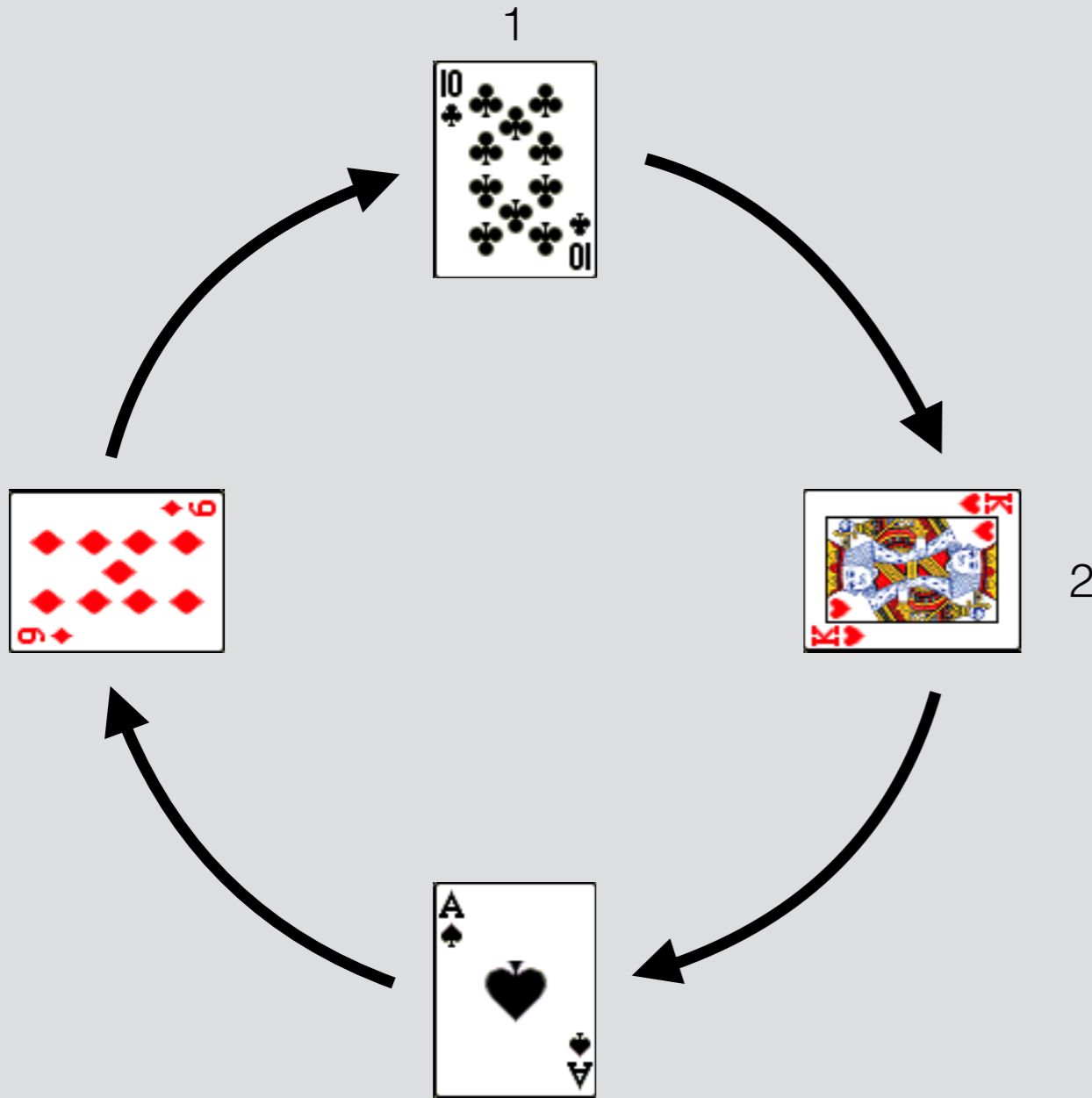
1. **Red Black**
2. **Black Red**
3. **Red Black**

# Order is important!



1. **Red Black**
2. **Black Red**
3. **Red Black**
4. **Black Red**

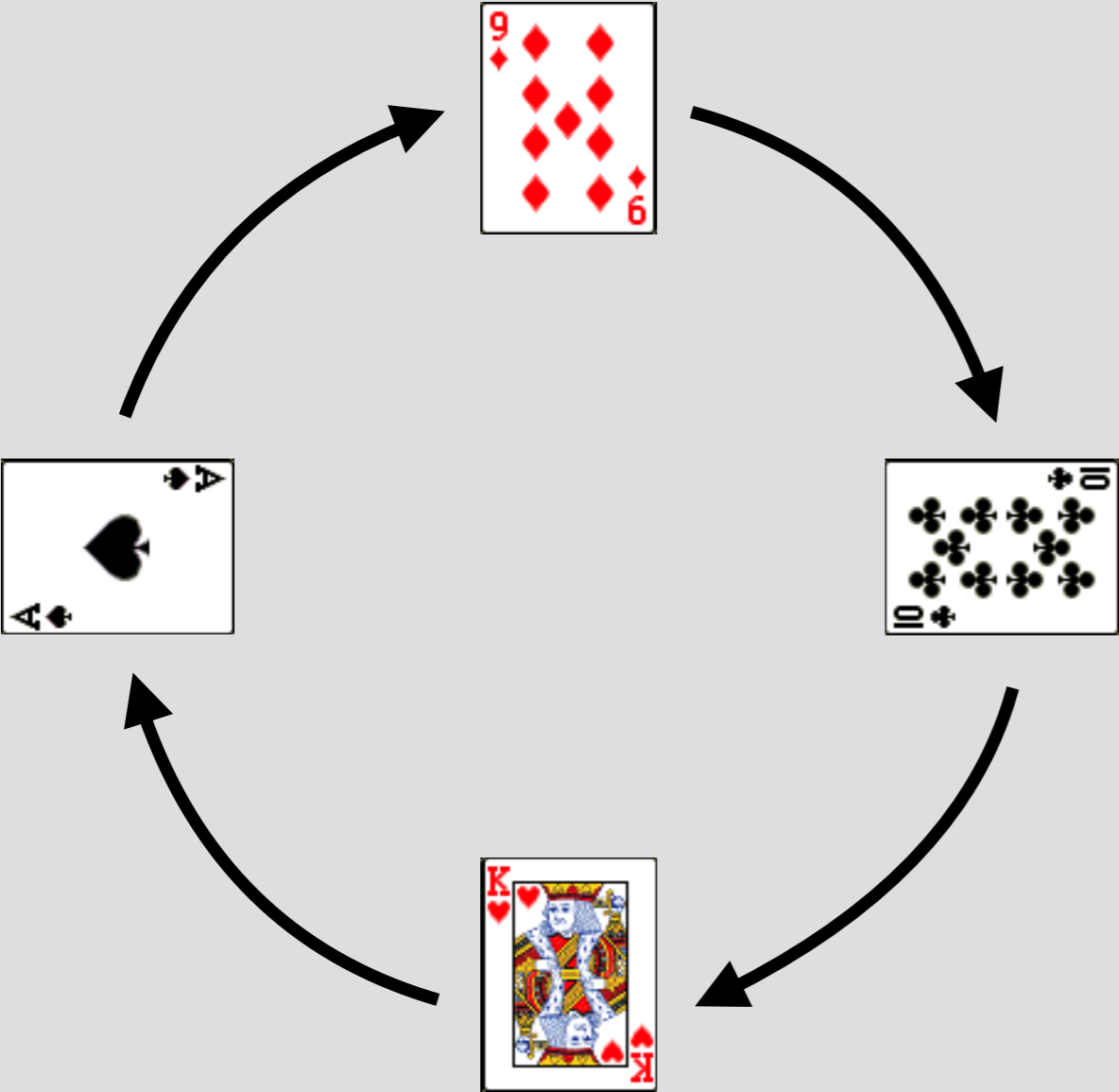
# Order is important!



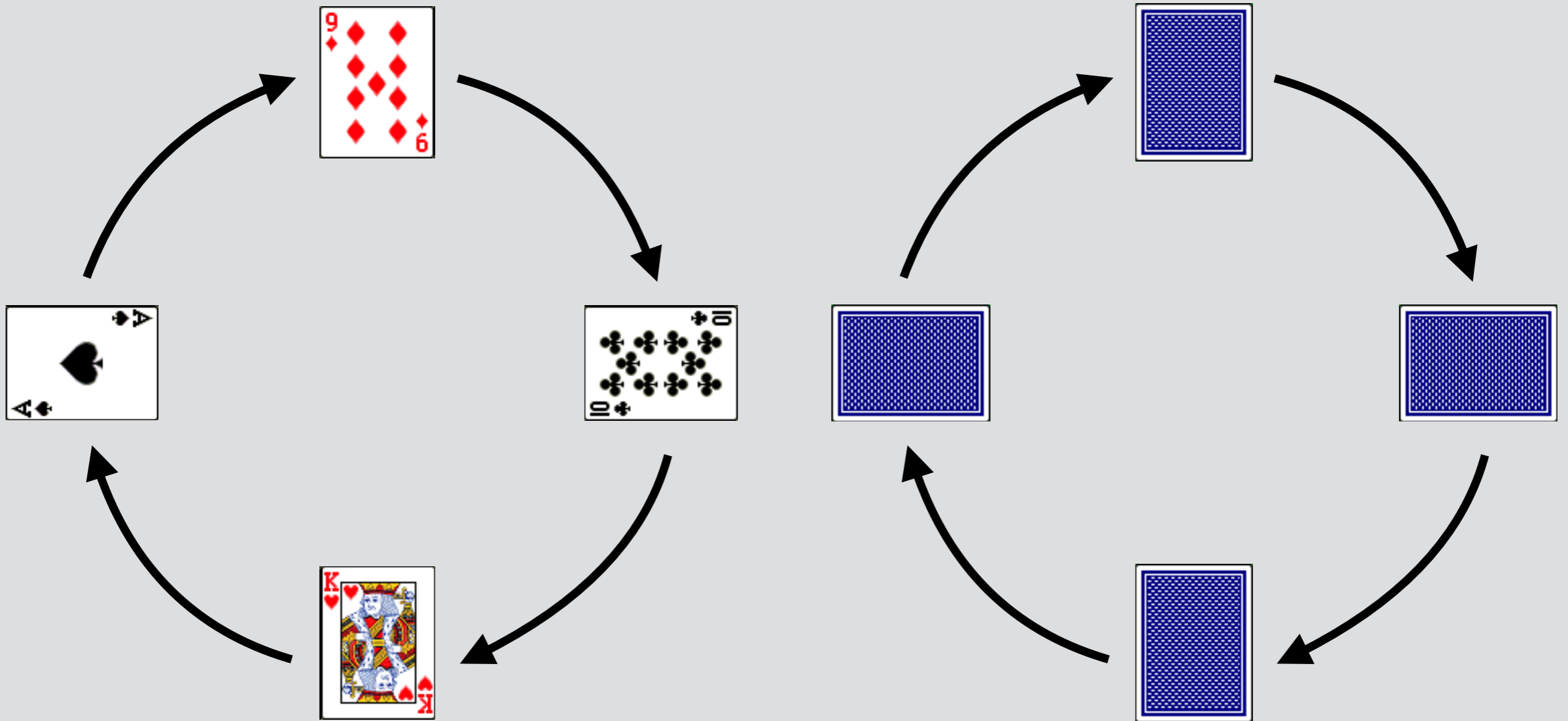
1. **Red Black**
2. **Black Red**
3. **Red Black**
4. **Black Red**

**Combinations repeat!**

# Order is important!

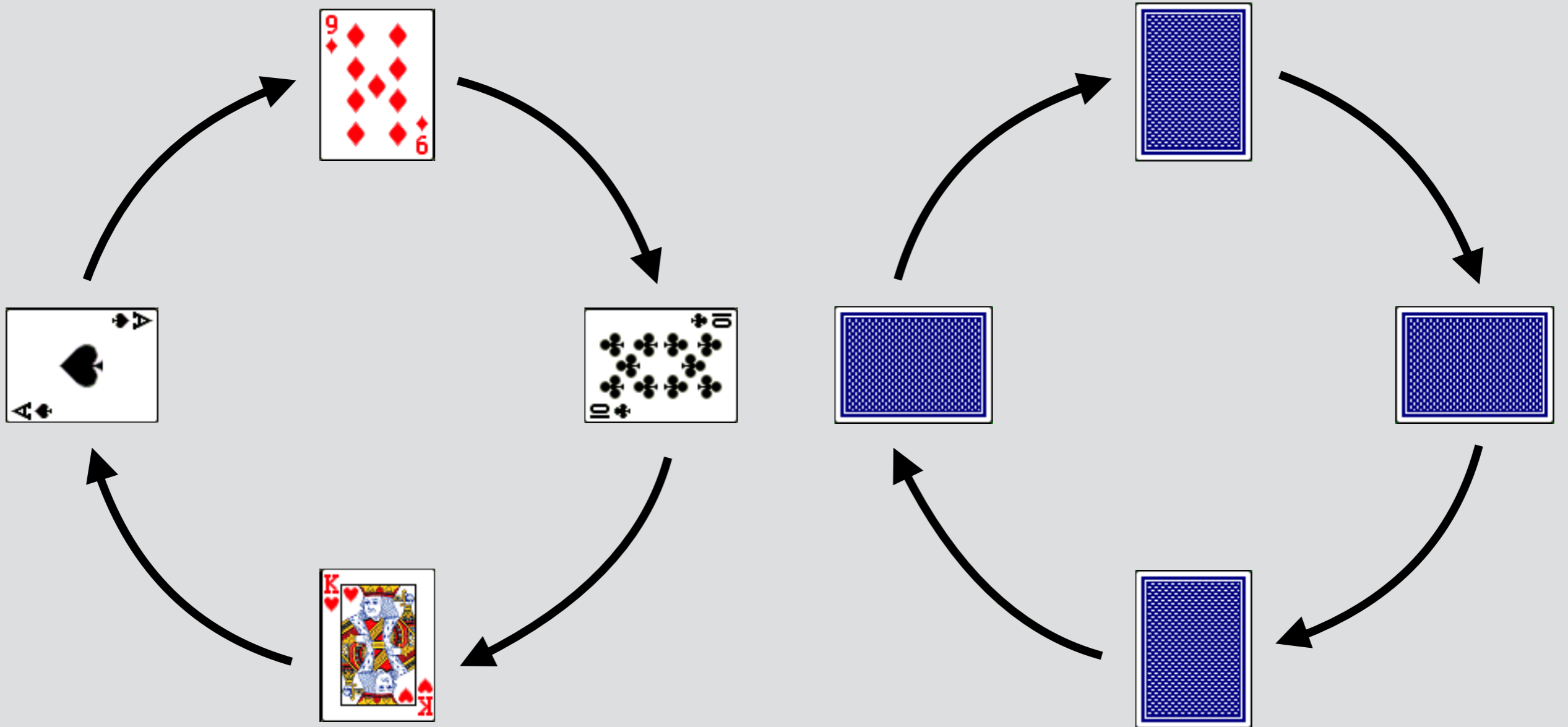


# Order is important!

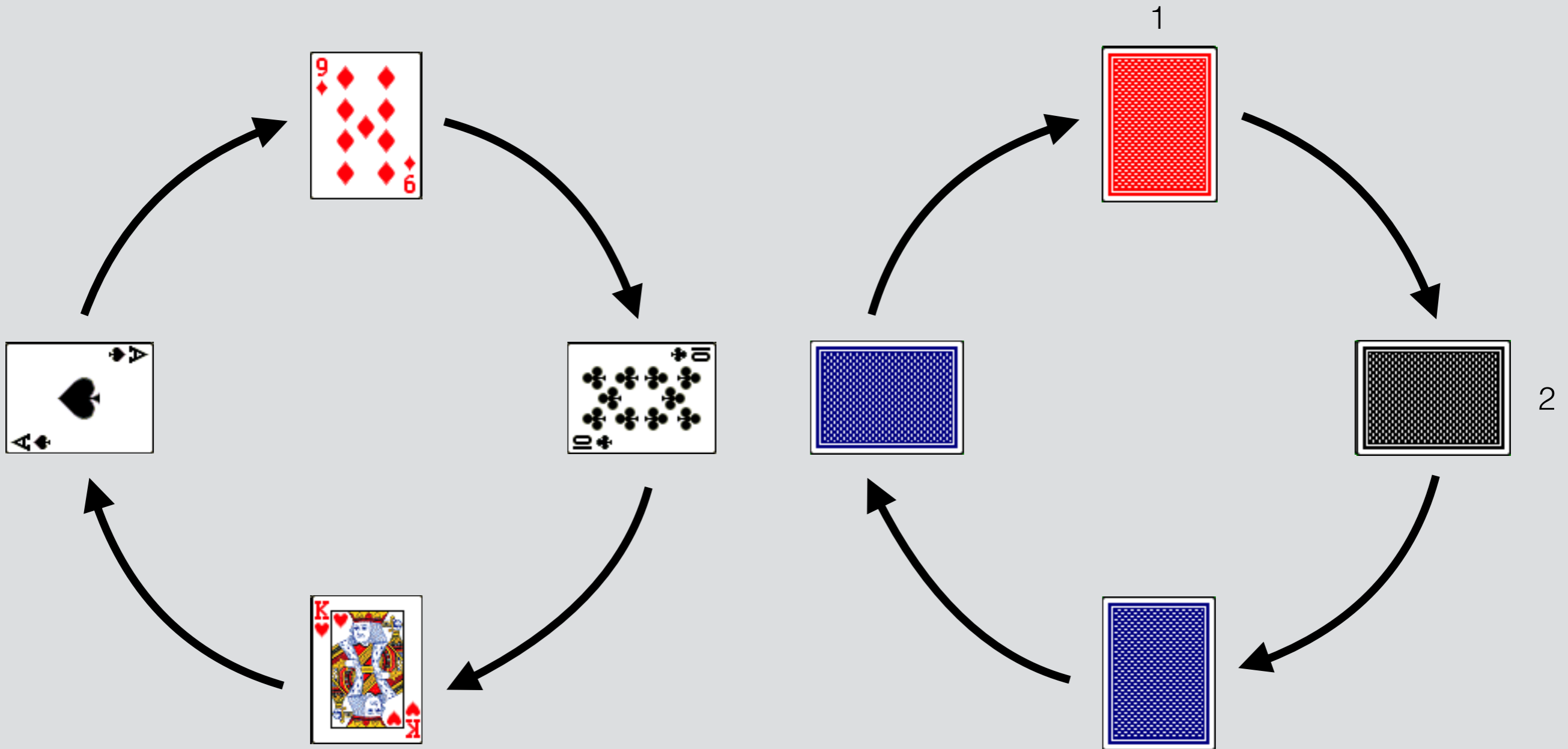




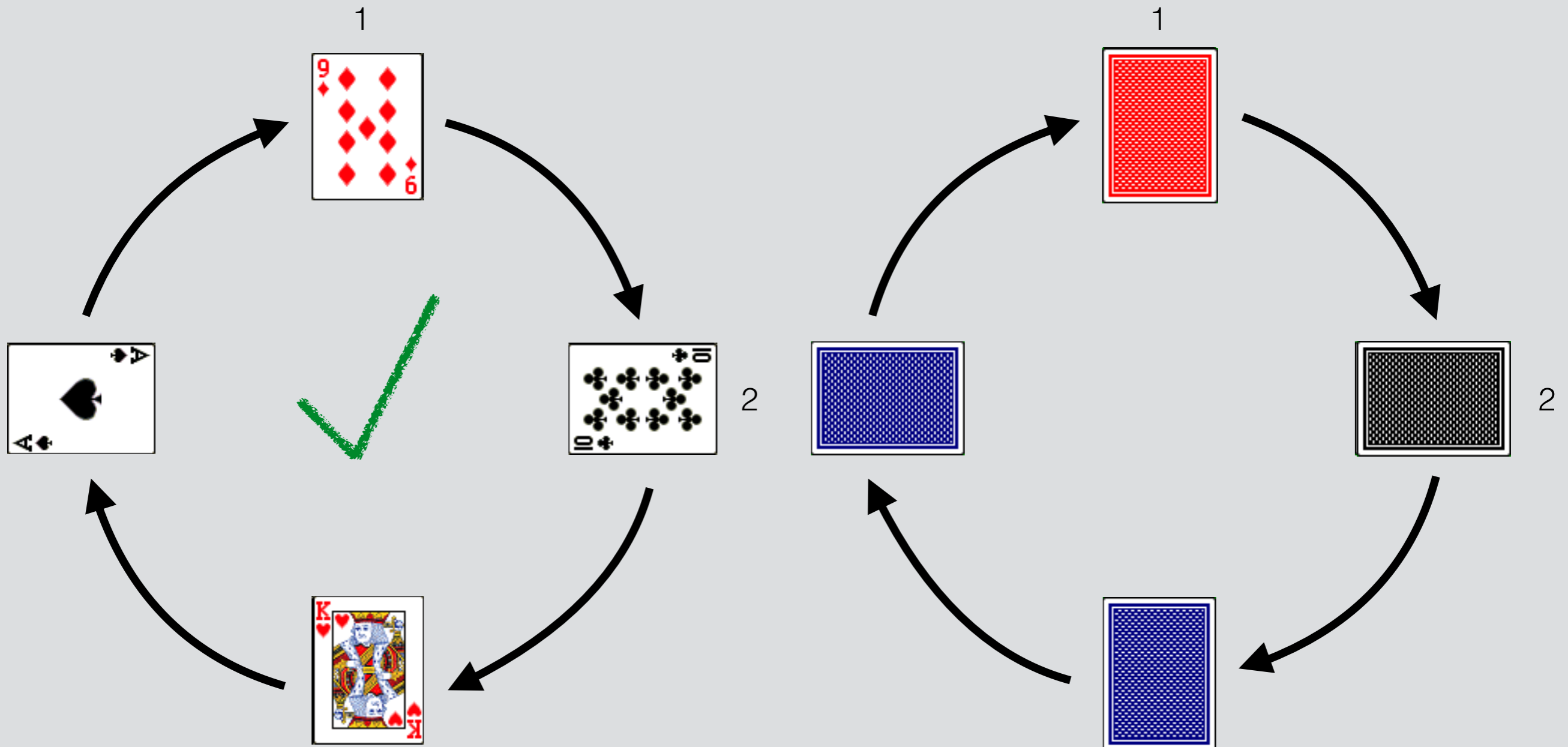
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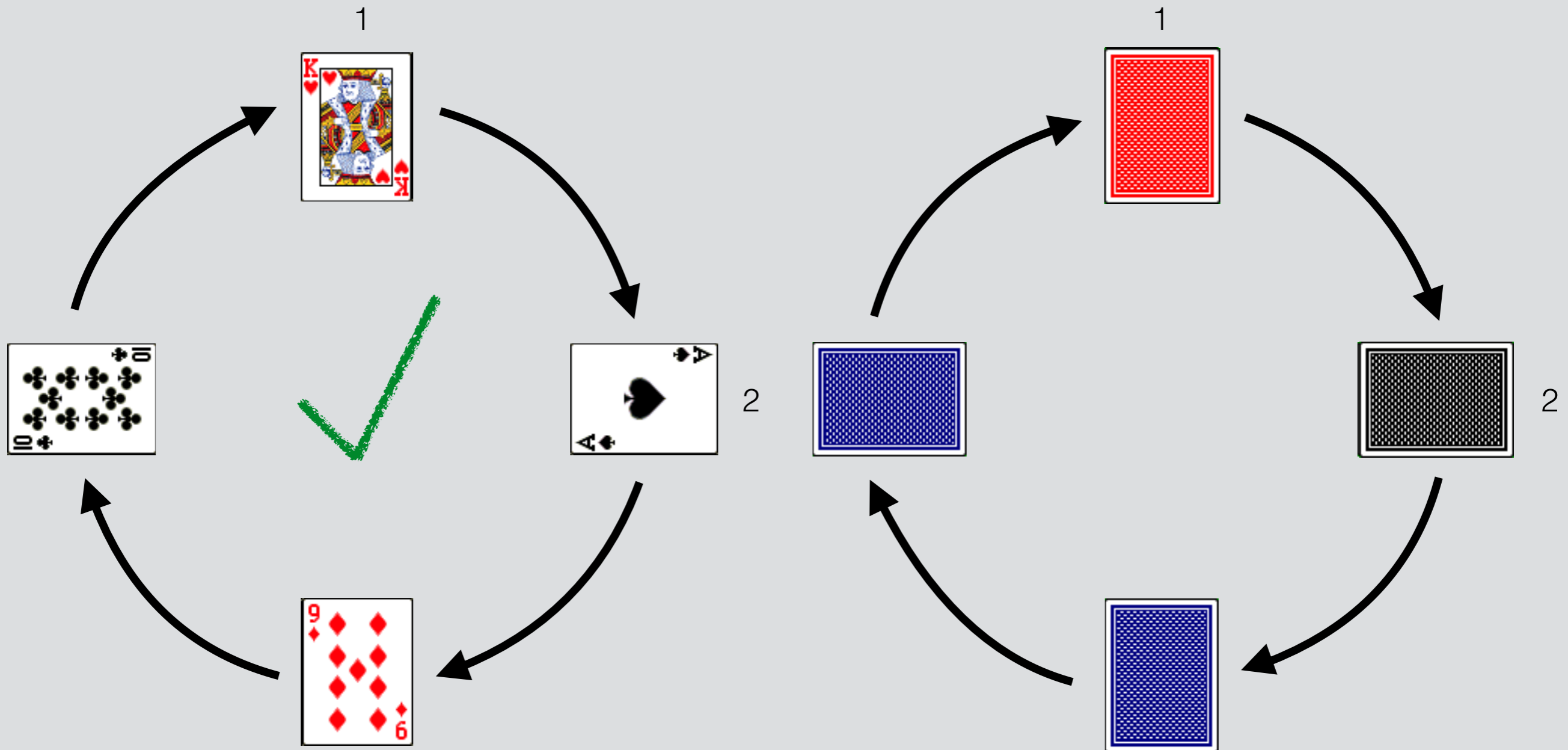
# Order is important!



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Uh oh :(

**What's special about the order?**

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**Every color combination only happens once!**

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**Every color combination only happens once!**

**Can we do this trick with more cards?**

**What's special about the order?**

**Every color combination only happens once!**

**Can we do this trick with more cards?**

**Yes, but we need longer combinations!**



# The Magic of de Bruijn Sequences

**Deck of 4 cards: 2 card combinations**

**BBRR**

# The Magic of de Bruijn Sequences

**Deck of 4 cards: 2 card combinations**

**BBRR**

**Deck of 8 cards: 3 card combinations**

# The Magic of de Bruijn Sequences

**Deck of 4 cards: 2 card combinations**

**BBRR**

**Deck of 8 cards: 3 card combinations**

**BBBRRRBR**

# The Magic of de Bruijn Sequences

**Deck of 4 cards: 2 card combinations**

**BBRR**

**Deck of 8 cards: 3 card combinations**

**BBBRRRBR**

**Deck of 16 cards: 4 card combinations**

# The Magic of de Bruijn Sequences

**Deck of 4 cards: 2 card combinations**

**BBRR**

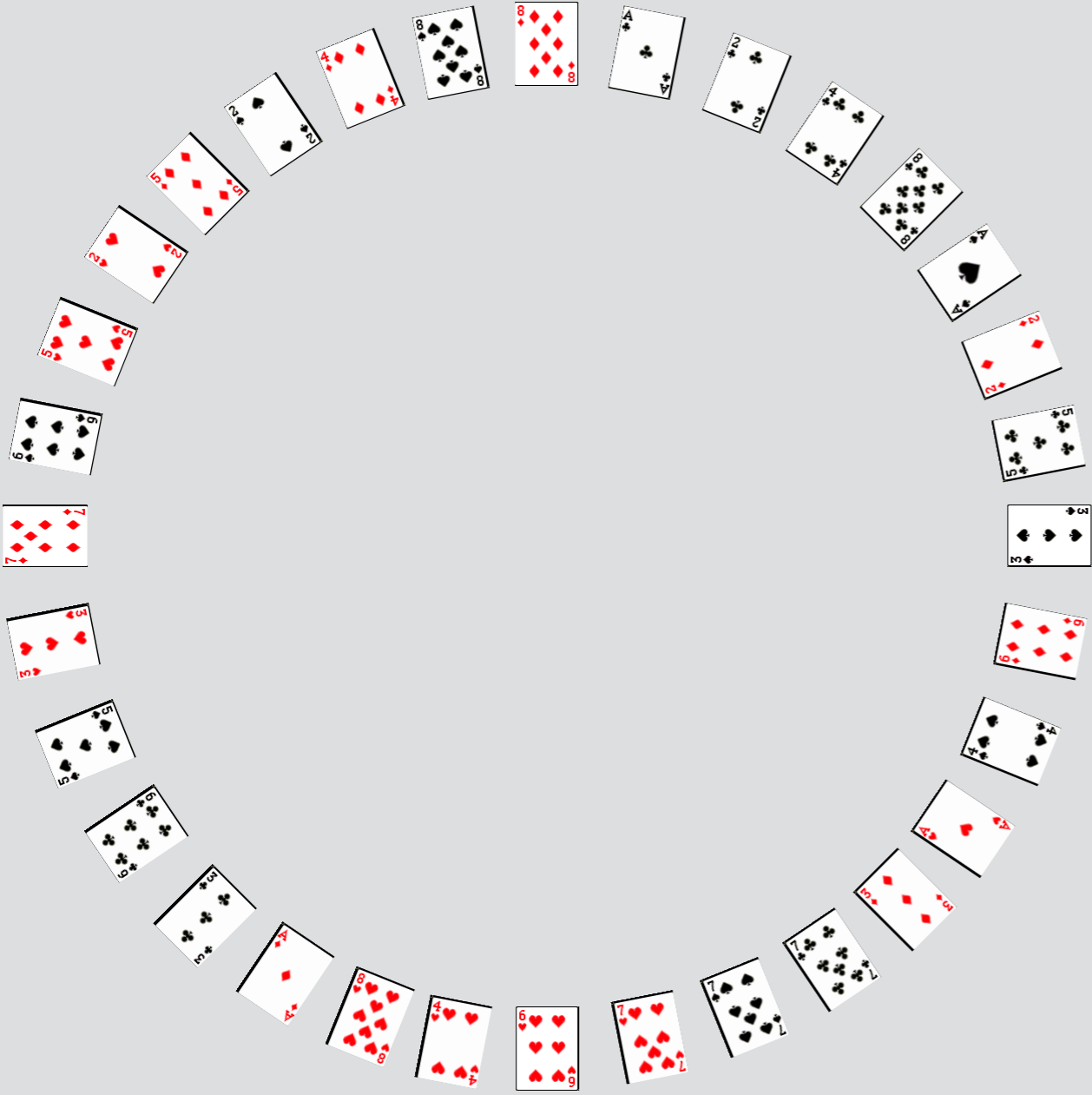
**Deck of 8 cards: 3 card combinations**

**BBBRRRBR**

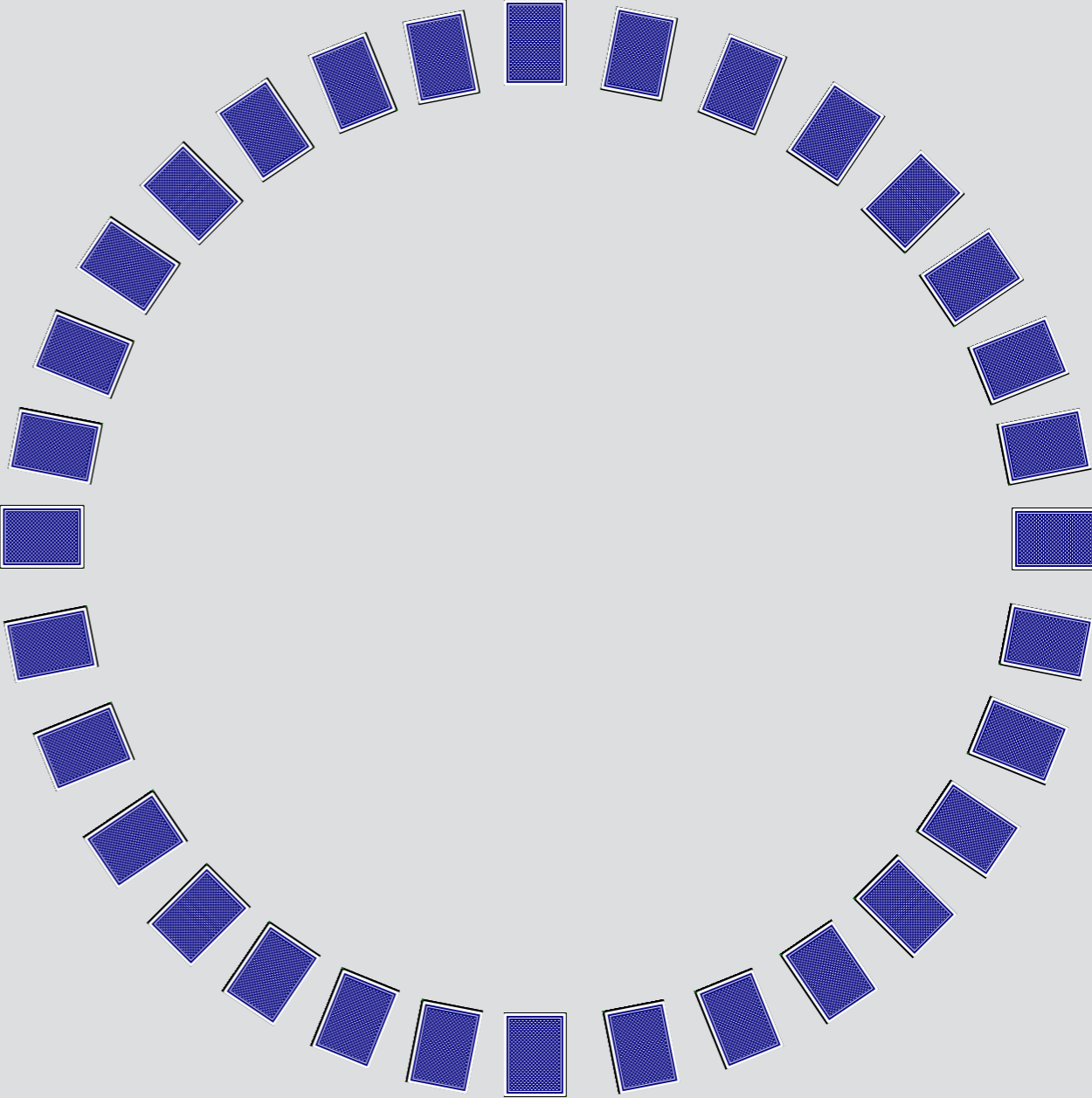
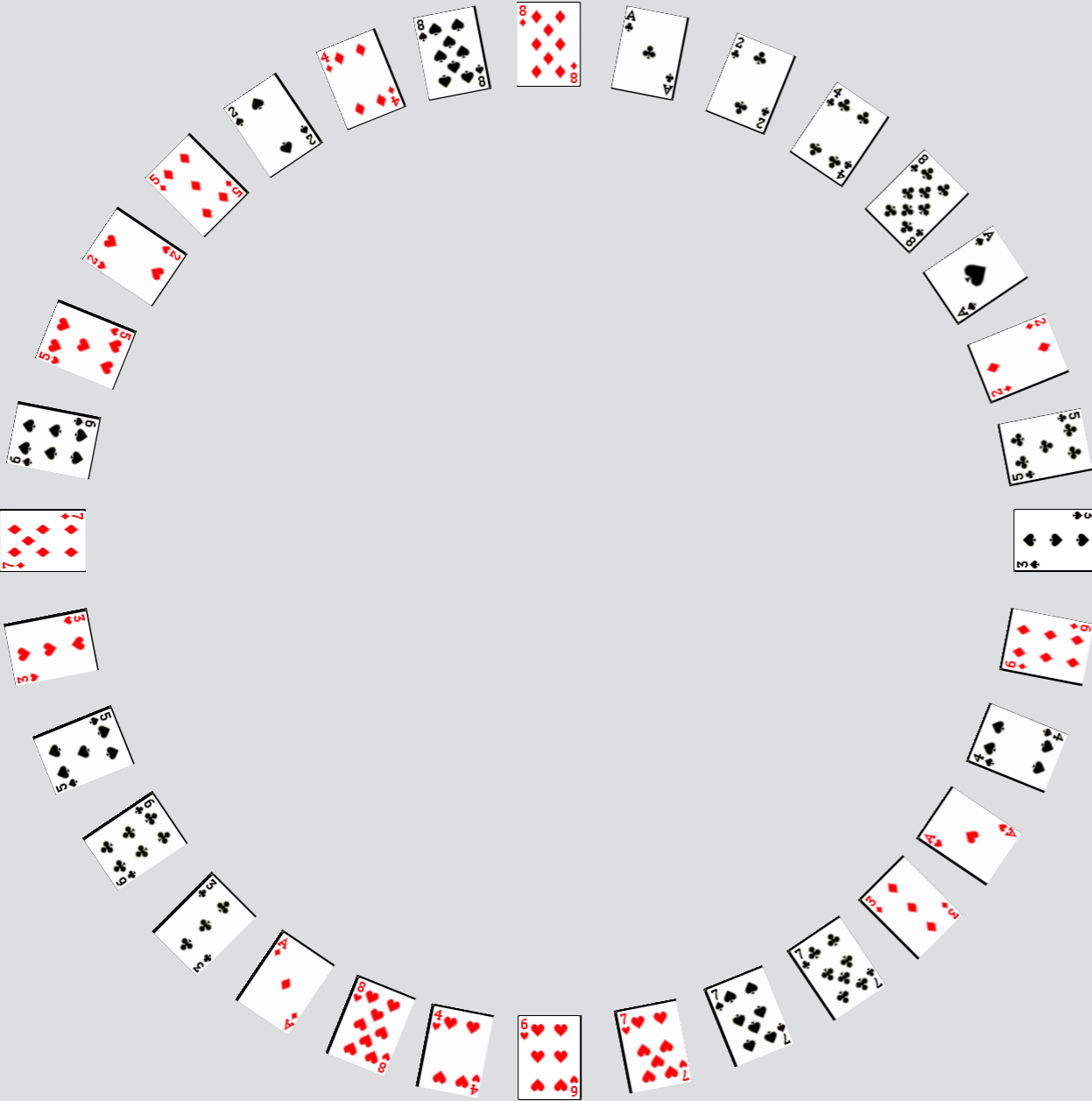
**Deck of 16 cards: 4 card combinations**

**BBBBRRRRBBRRBR**

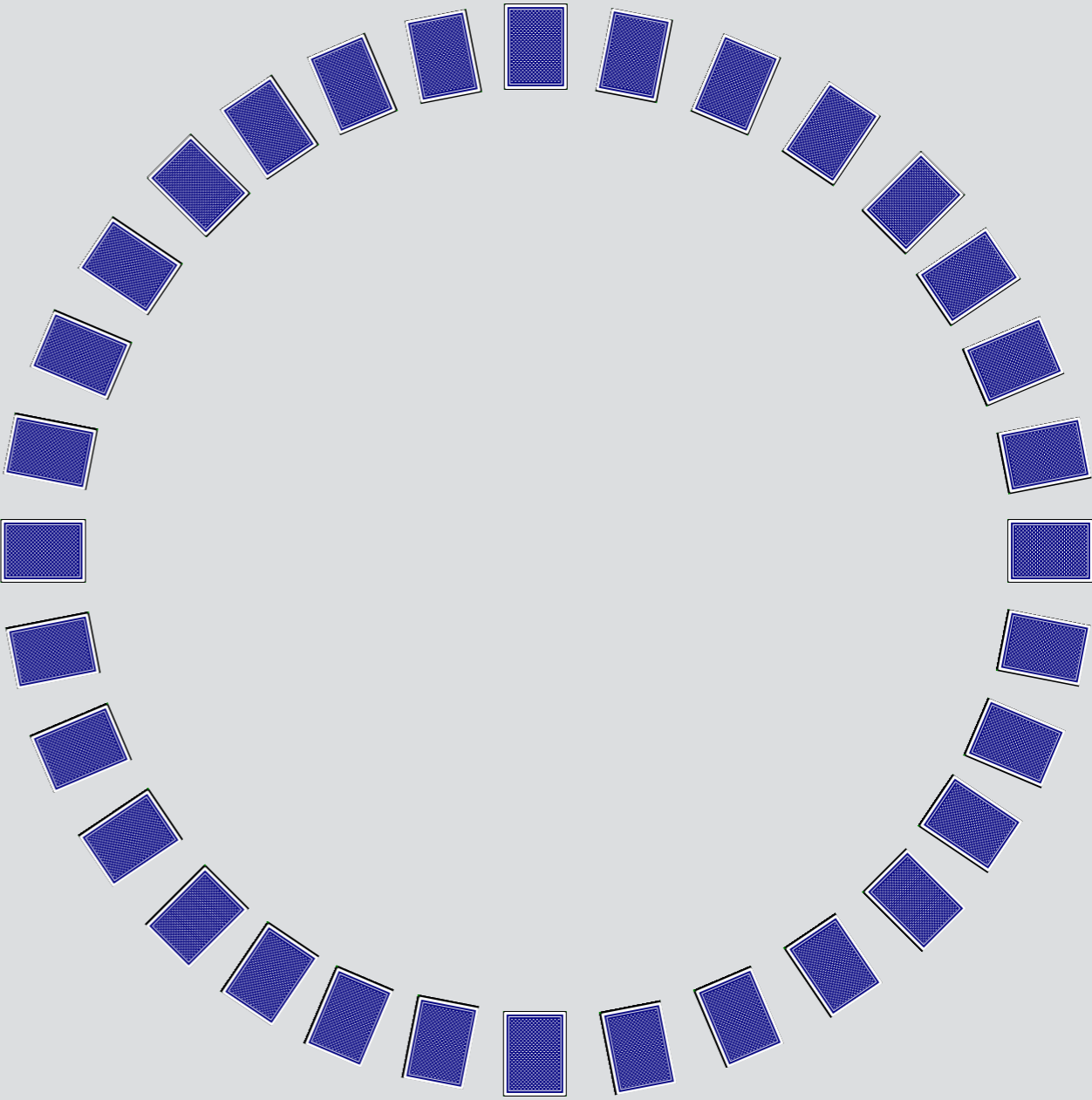
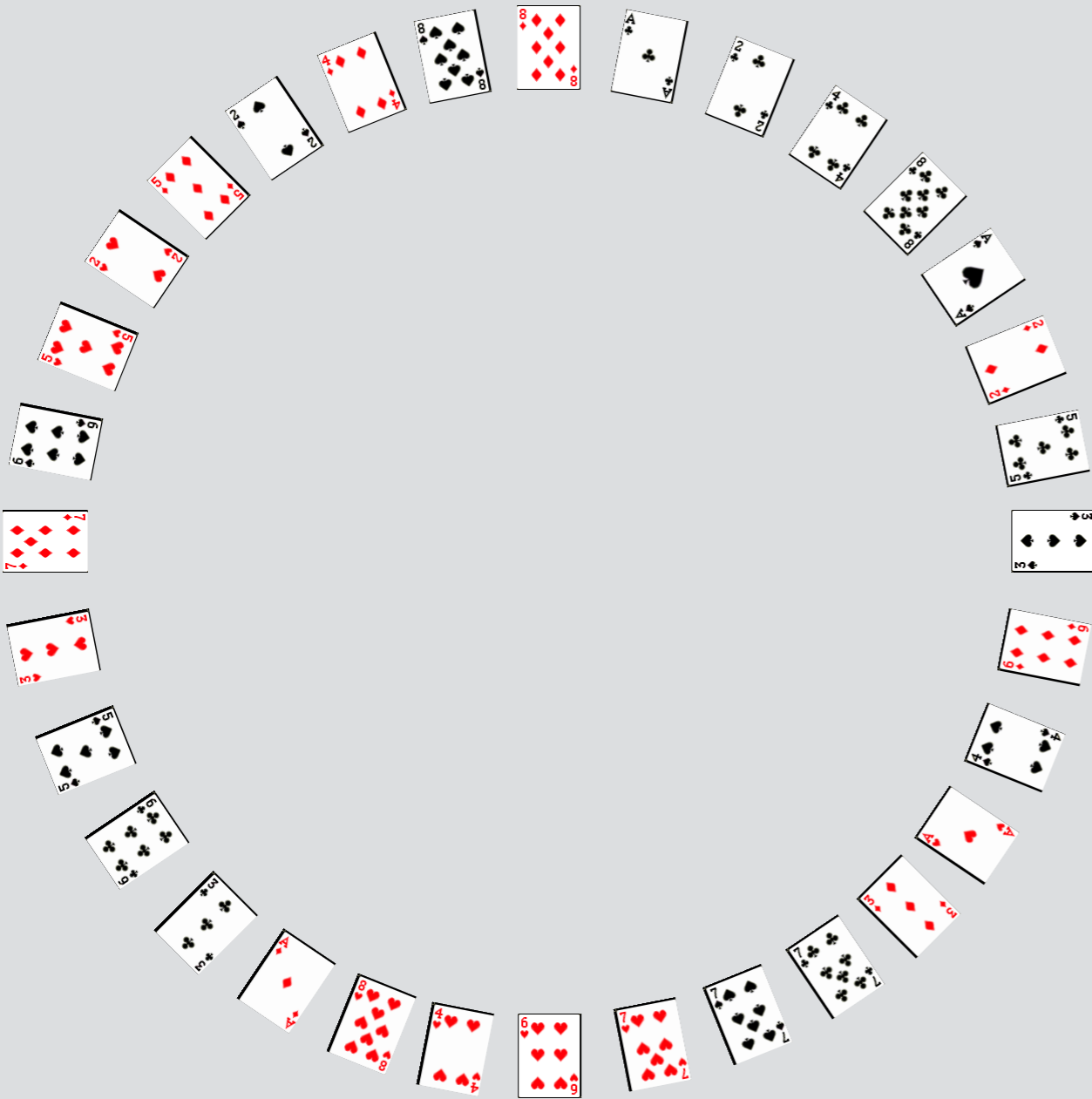
# Deck of 32 cards: 5 card combinations



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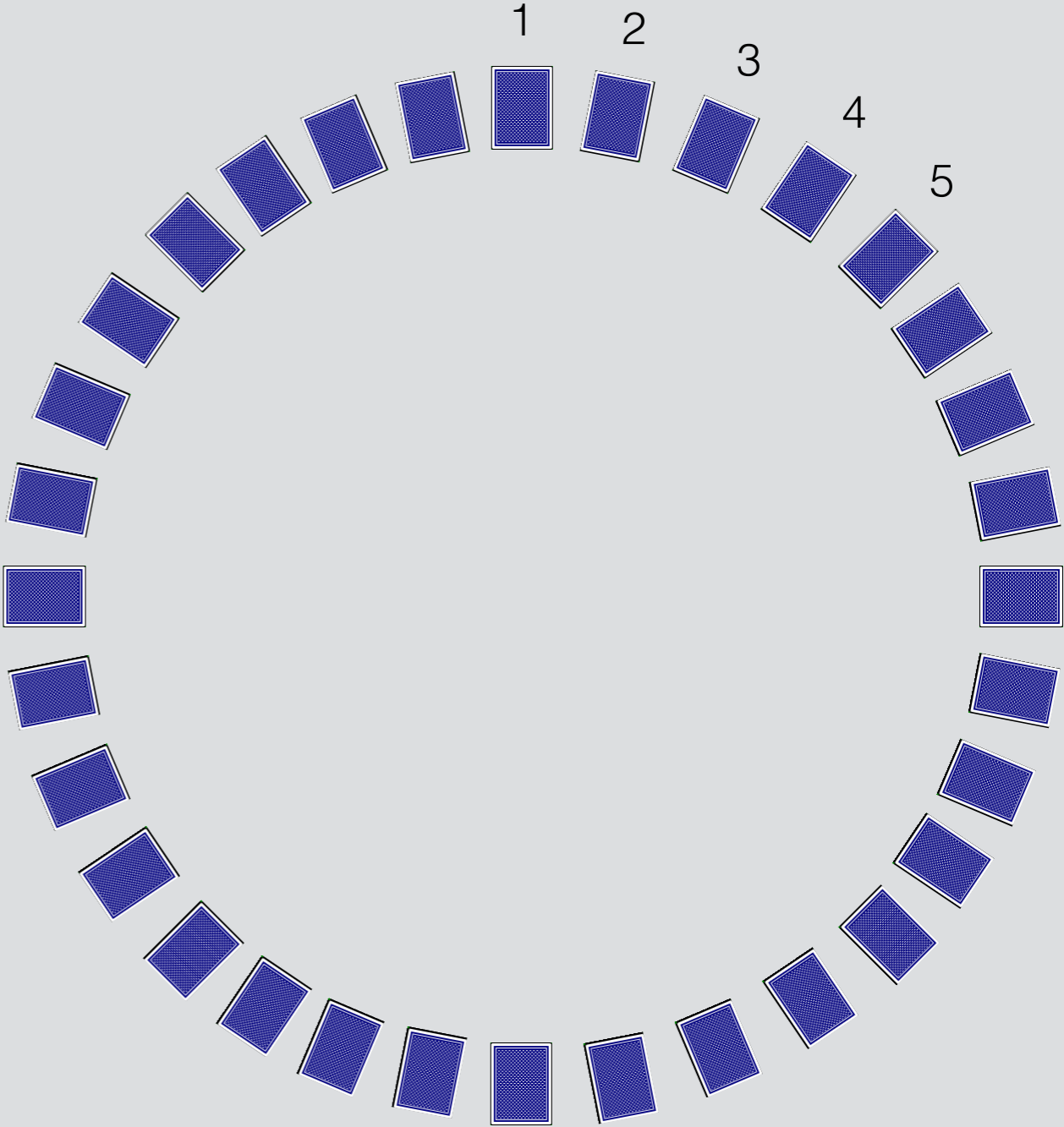
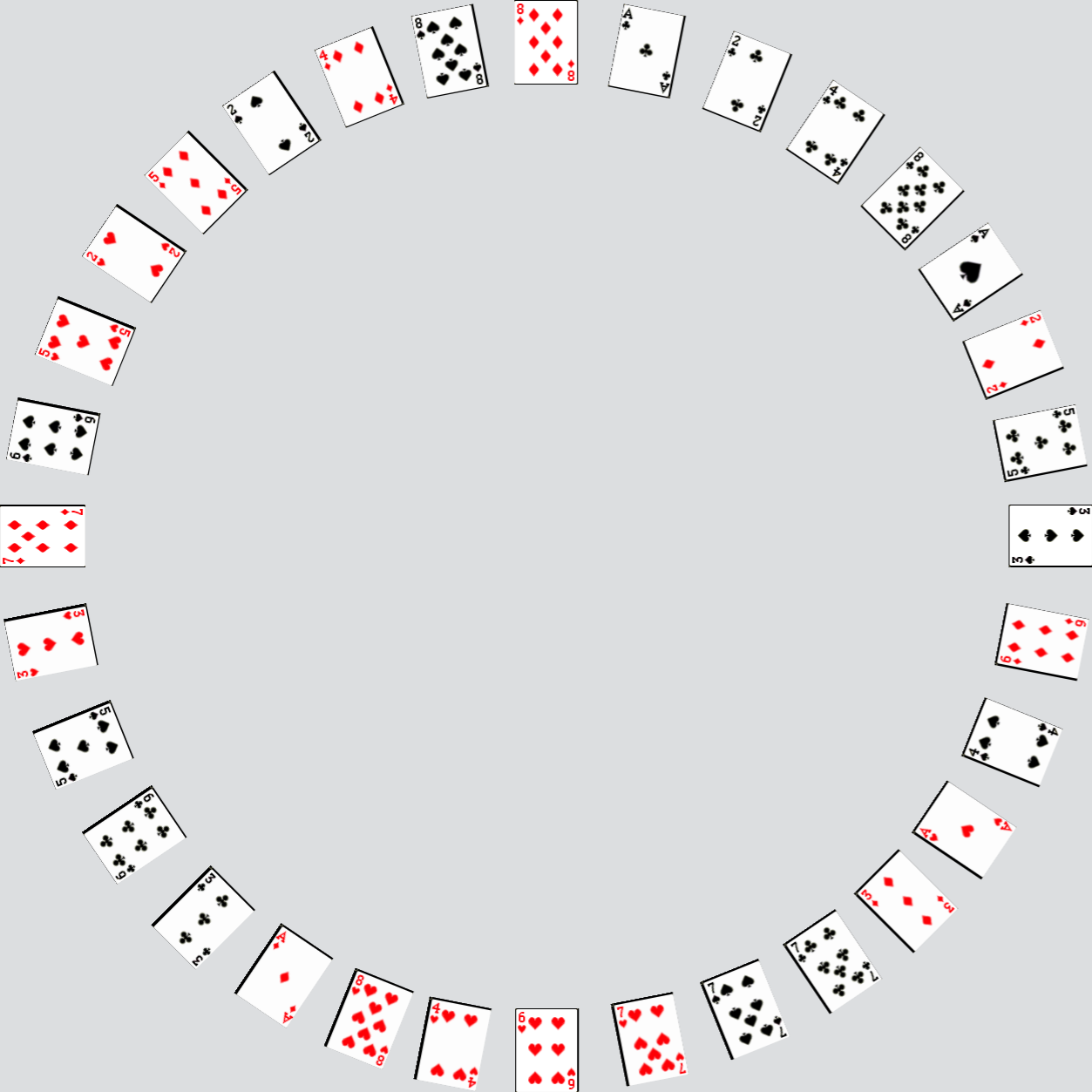


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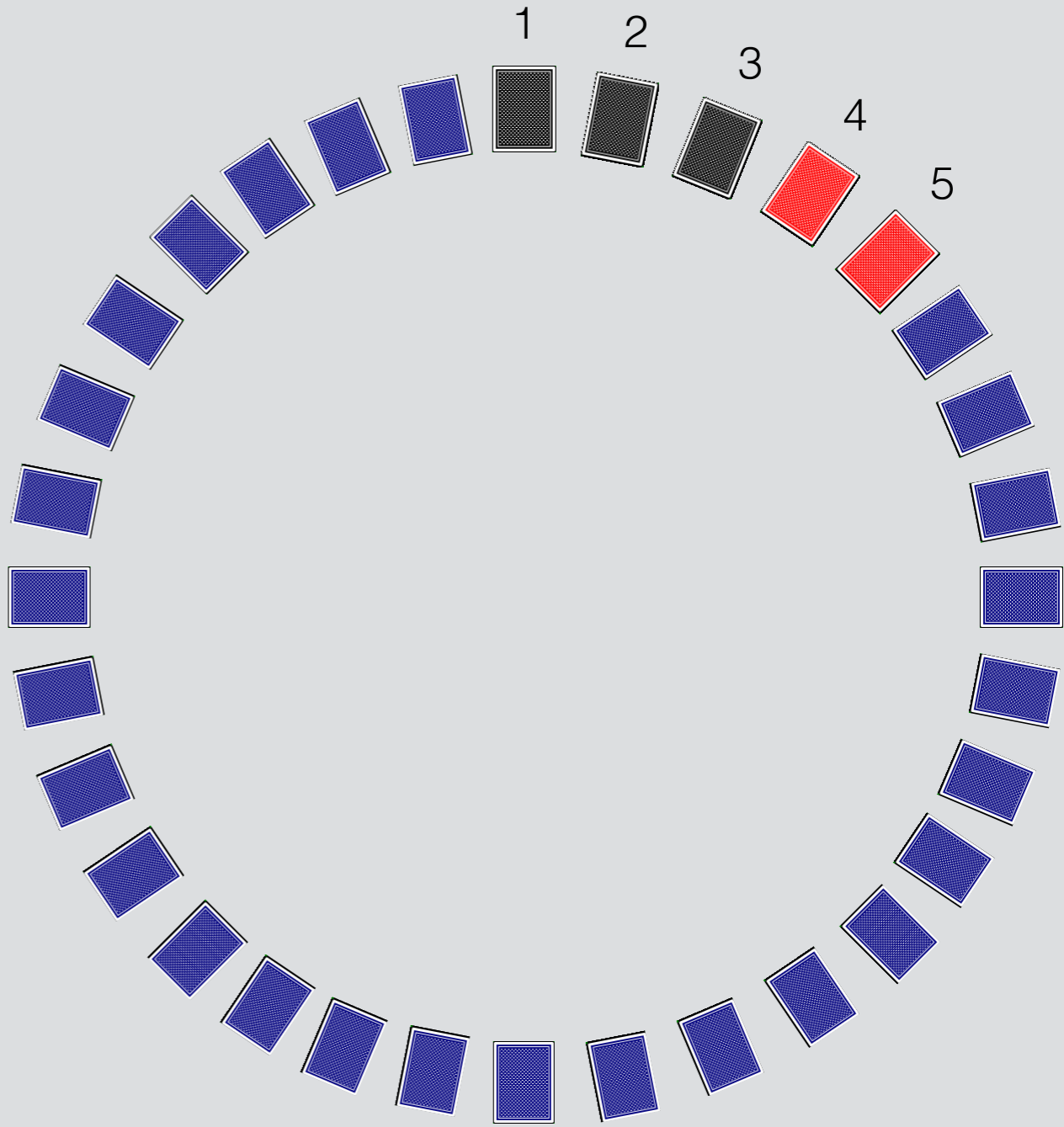
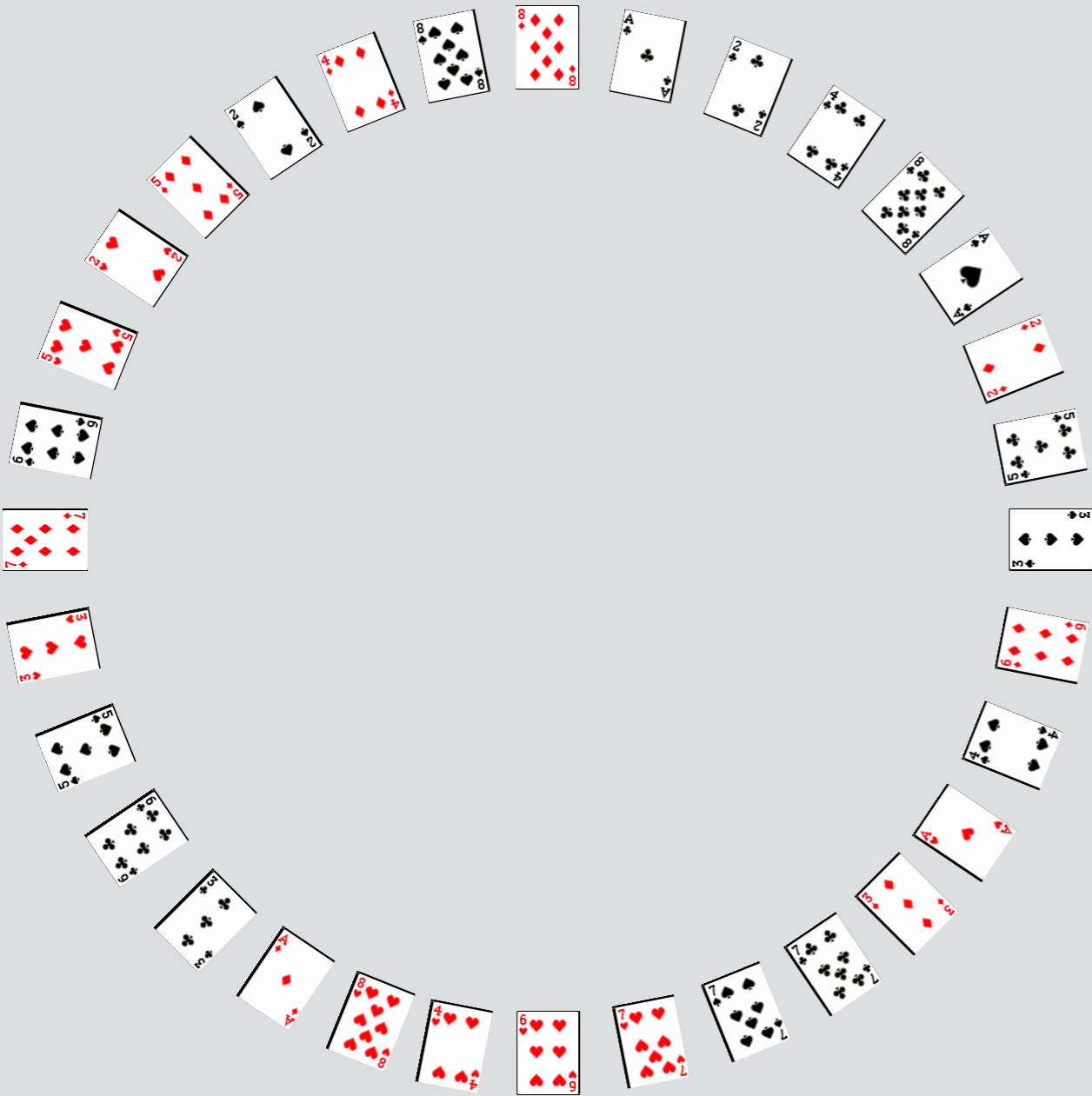




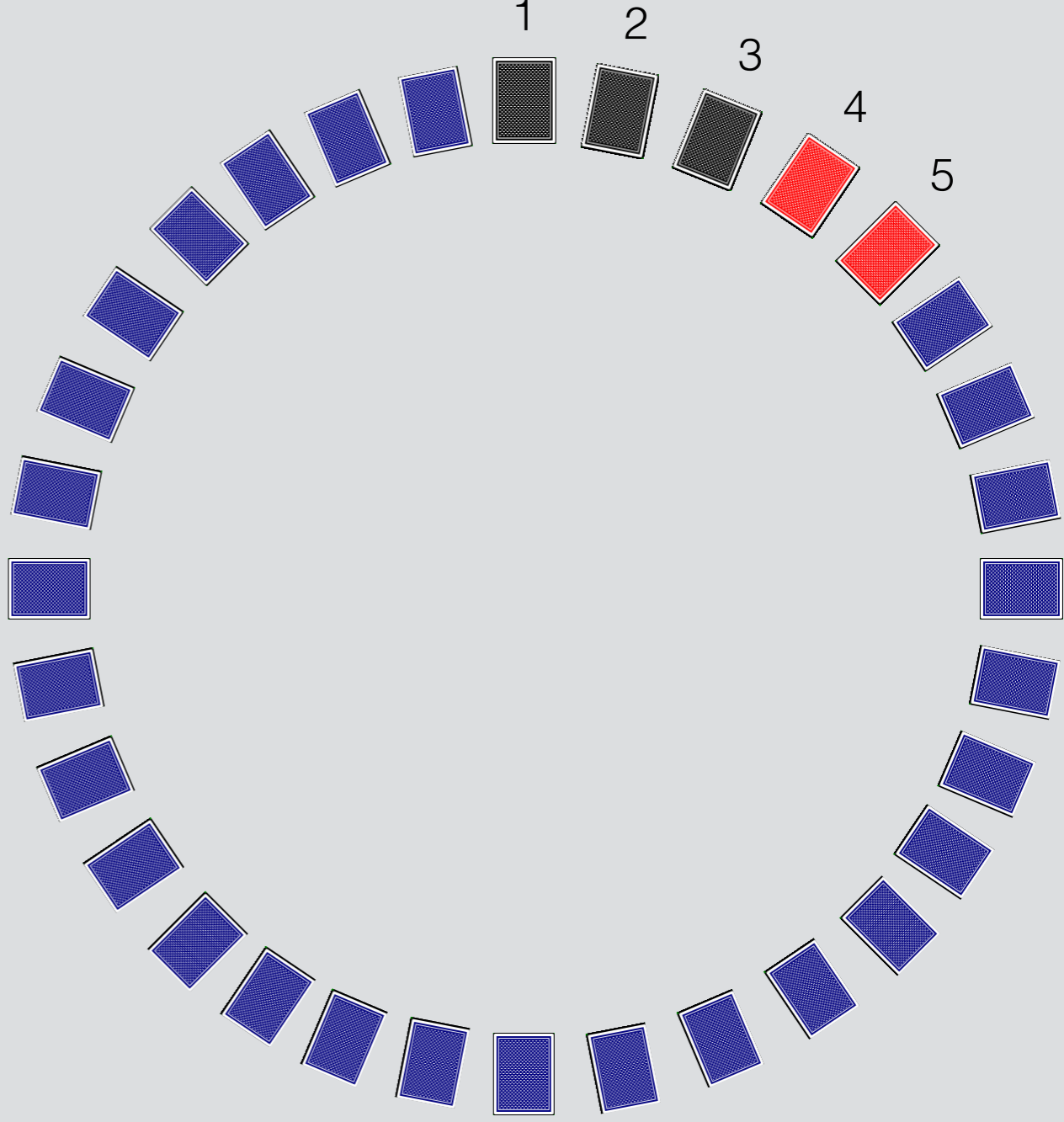
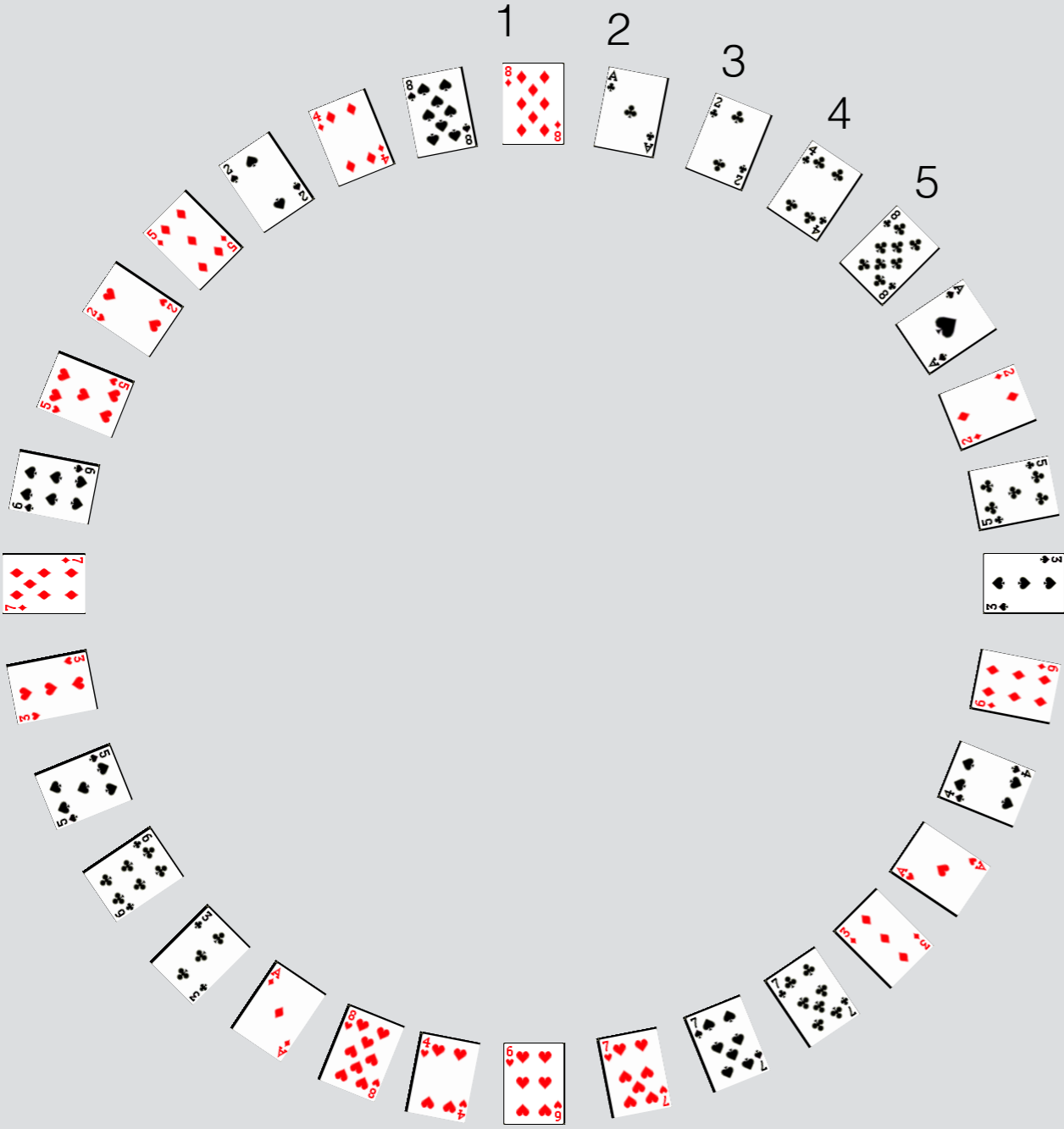
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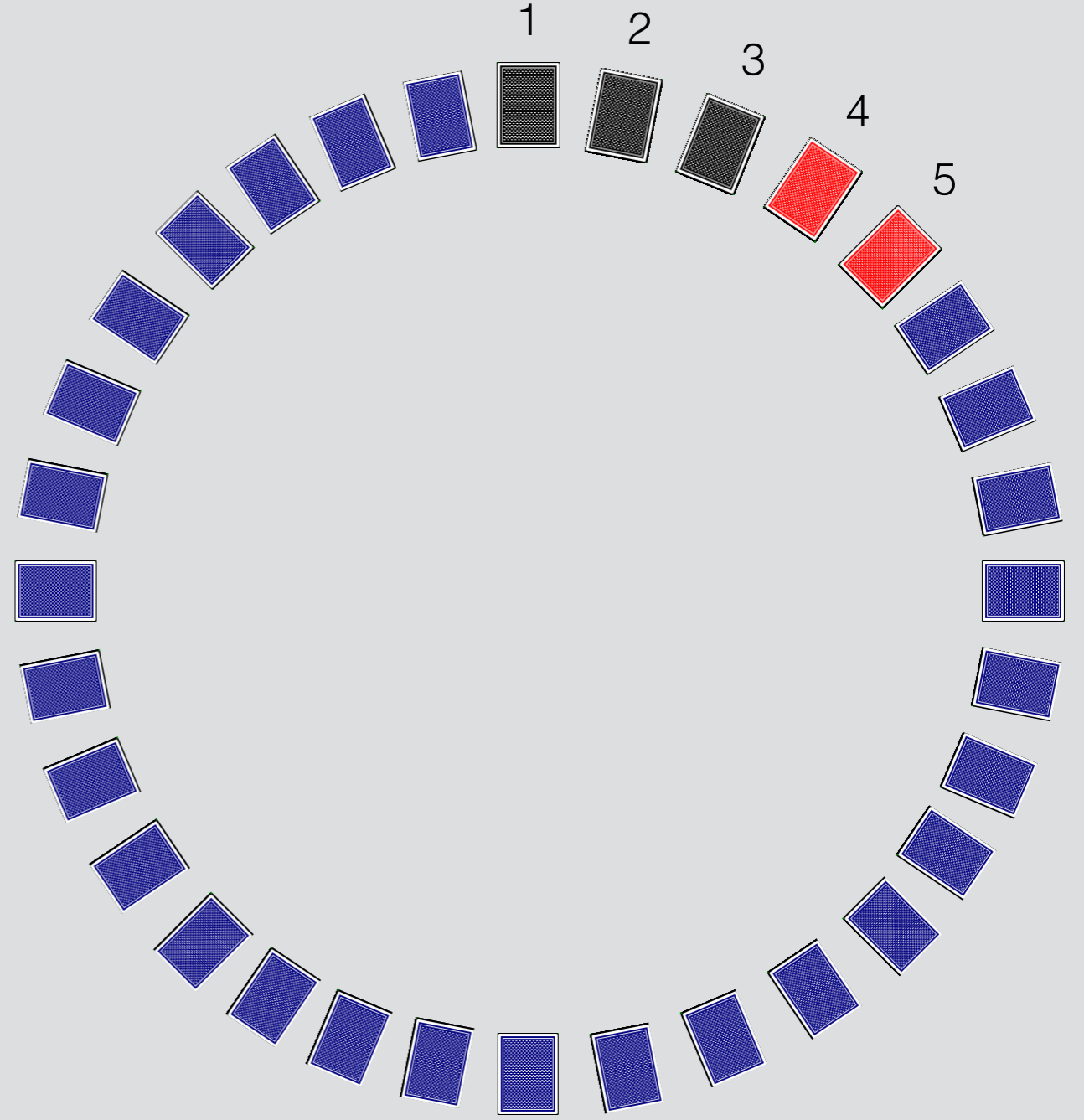
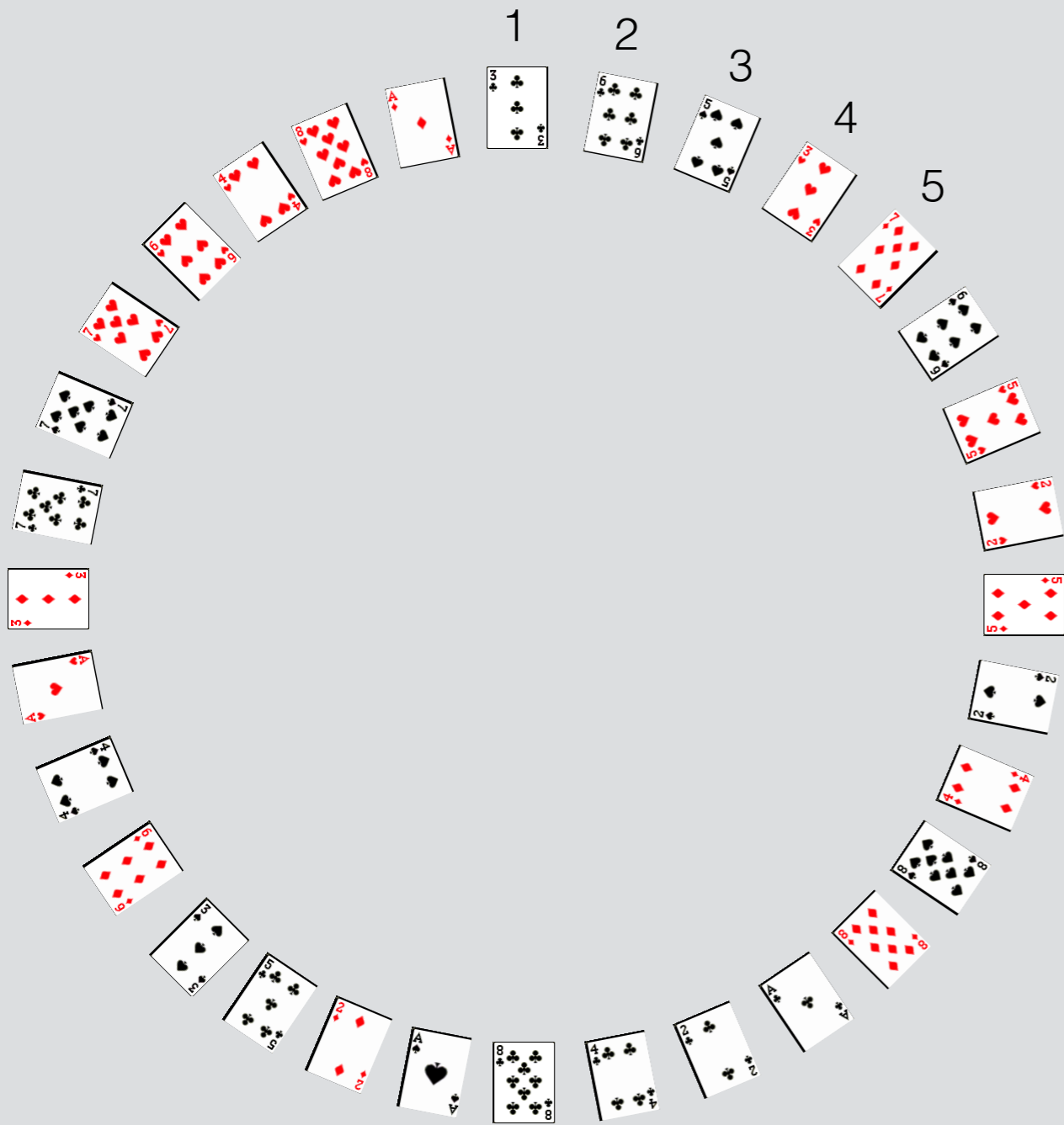
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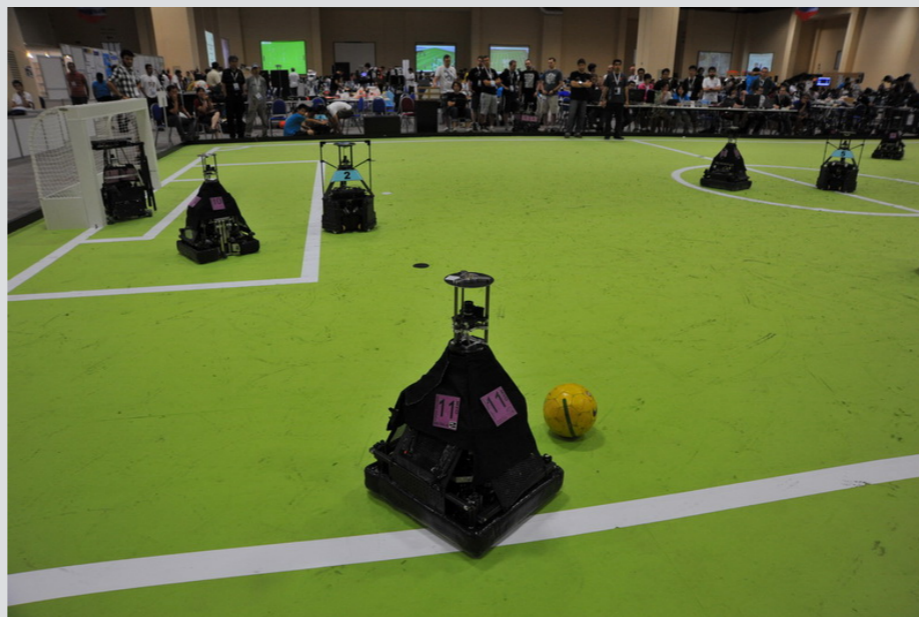
# The Magic of de Bruijn Sequences



**Reading DNA**



**Secret codes**



**Robot vision**

# Magical Mathematics!



**Persi Diaconis**



**Ron Graham**