



$$\mathbb{C}\mathfrak{S}_n \cong \bigoplus_{\lambda \vdash n} M^{f^\lambda} \times f^\lambda$$

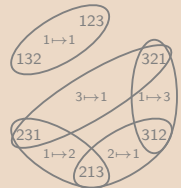
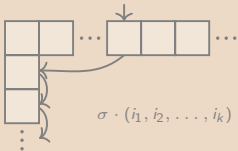
# Long Increasing Subsequences

Permutations, RSK Tableaux,  
and Chutes and Ladders

Hannah Friedman

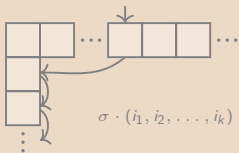
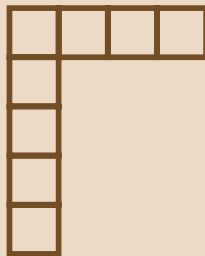
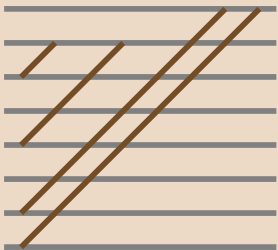
Harvey Mudd College

May 1, 2023

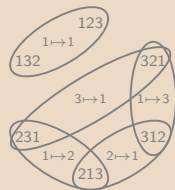




$$\mathbb{C}\mathfrak{S}_n \cong \bigoplus_{\lambda \vdash n} M^{f^\lambda} \times f^\lambda$$



$$\sigma \cdot (i_1, i_2, \dots, i_k) = (\sigma(i_1), \sigma(i_2), \dots, \sigma(i_k))$$

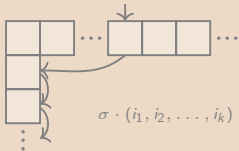




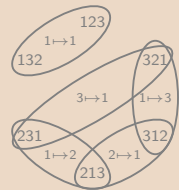
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A permutation is a bijection  $\sigma : \{1, 2, \dots, n\} \rightarrow \{1, 2, \dots, n\}$ .

1	2	3	4	5	6	7	8
↓	↓	↓	↓	↓	↓	↓	↓
5	1	3	8	4	6	2	7



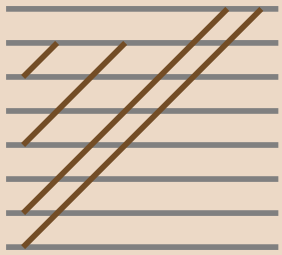
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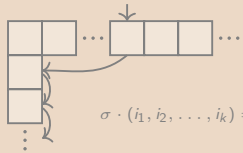
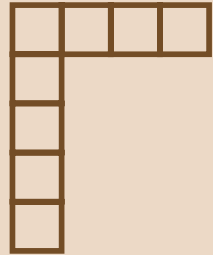


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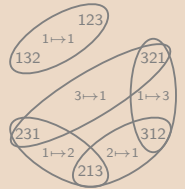
Reduced Words



RSK Tableaux

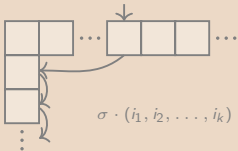
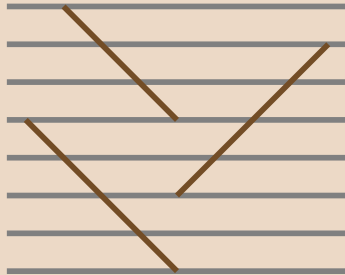


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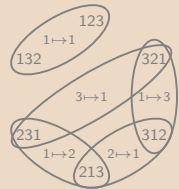




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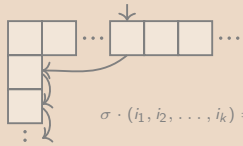
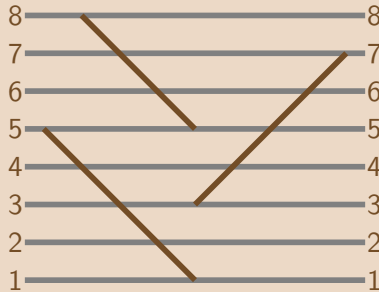


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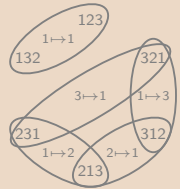




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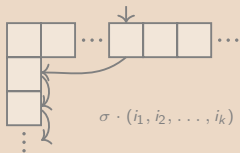
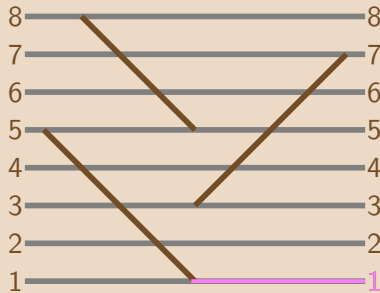


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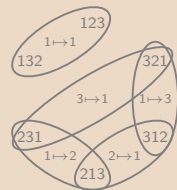




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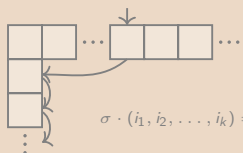
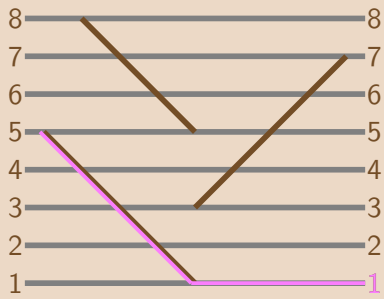


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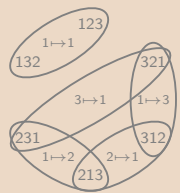




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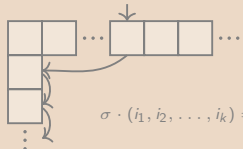
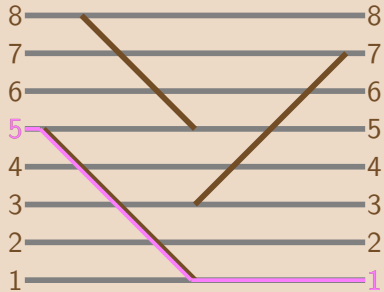




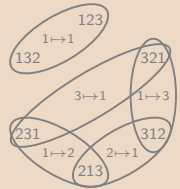


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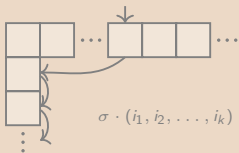
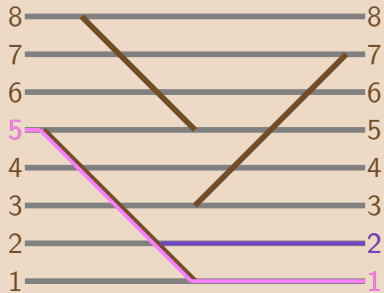
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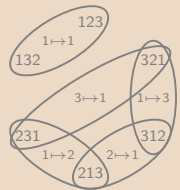


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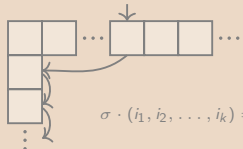
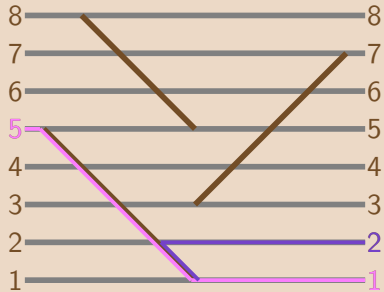
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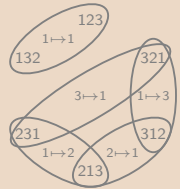


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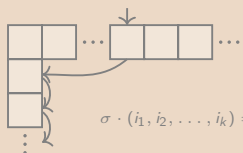
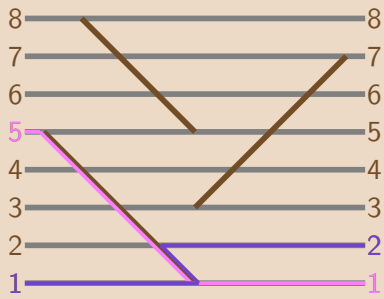
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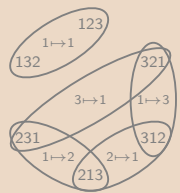


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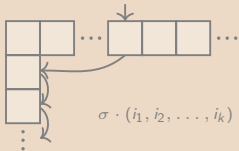
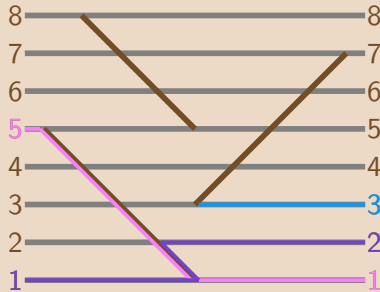
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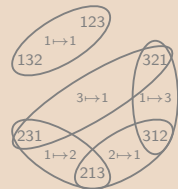


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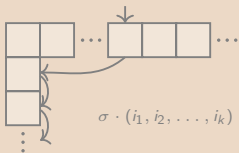
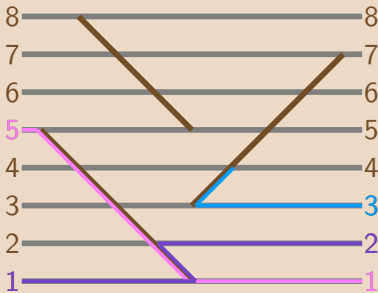
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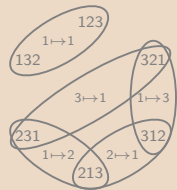


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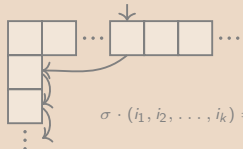
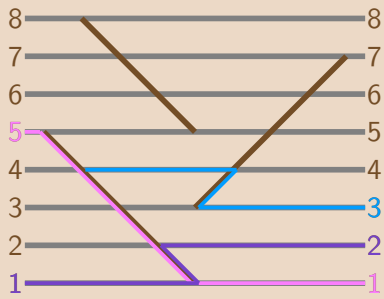
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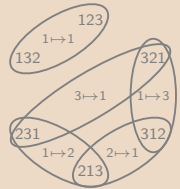


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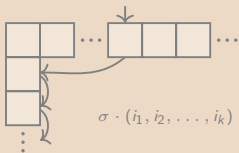
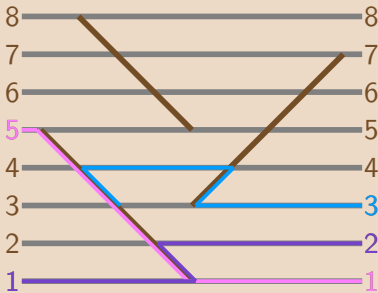
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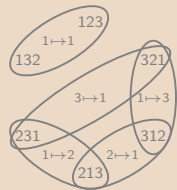


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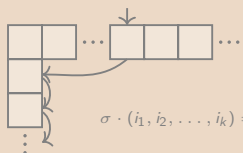
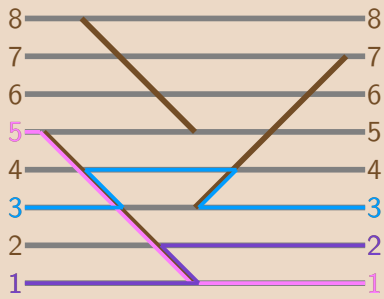




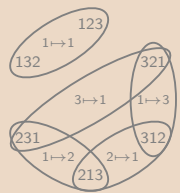


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1 2 3  
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 5 1 3



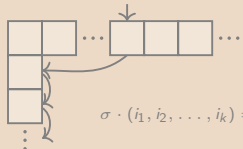
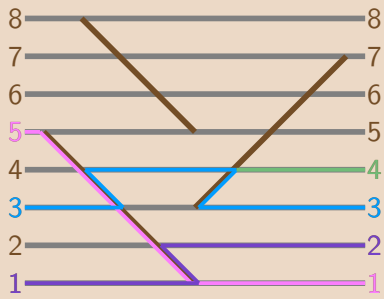
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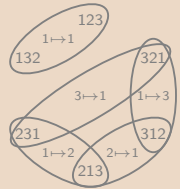


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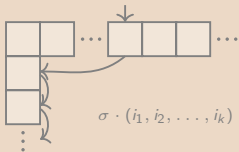
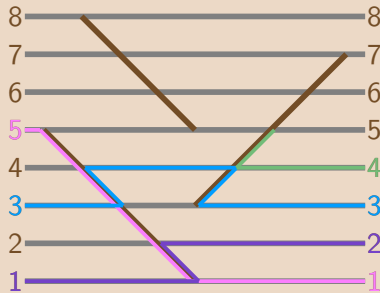
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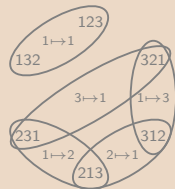


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1 2 3  
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 5 1 3



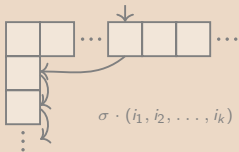
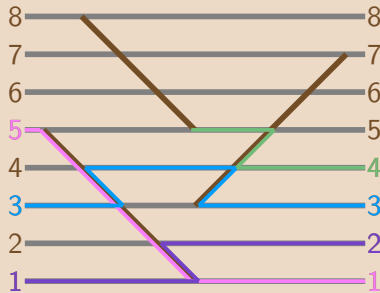
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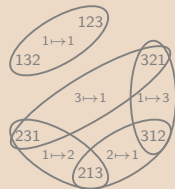


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 5 1 3



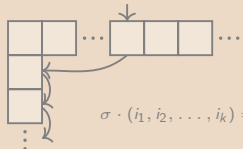
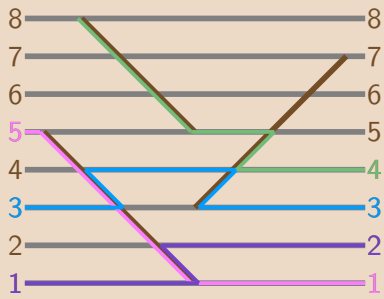
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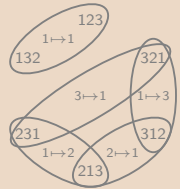


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 5 1 3

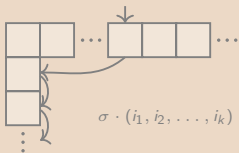
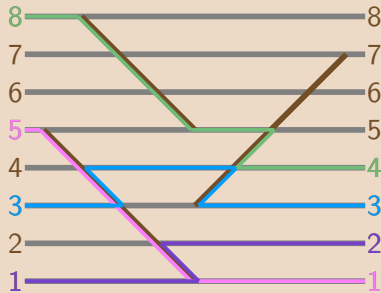


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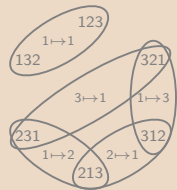




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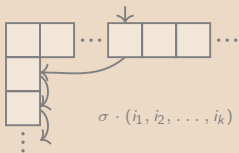
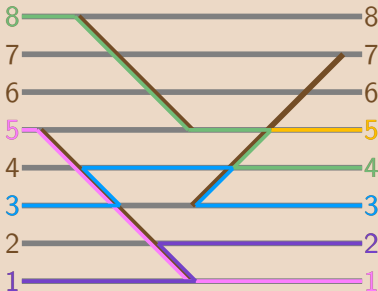
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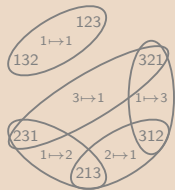


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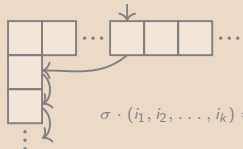
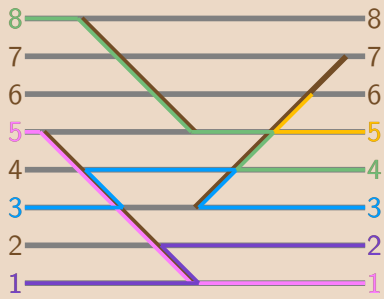
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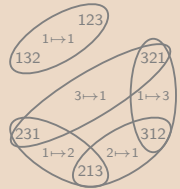


$$\mathbb{C}\mathfrak{S}_n \cong \bigoplus_{\lambda \vdash n} M^{f^\lambda} \times f^\lambda$$

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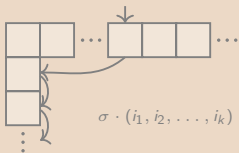
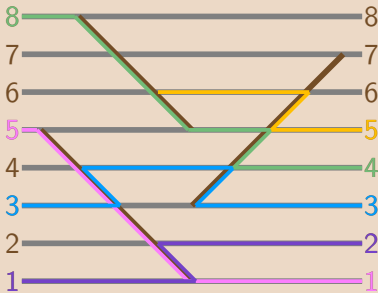




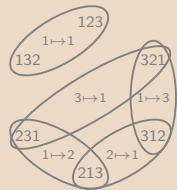


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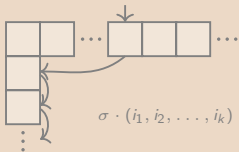
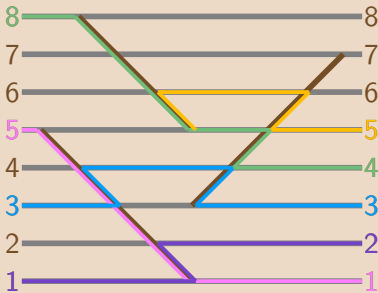
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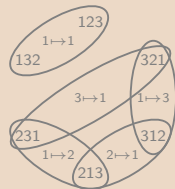


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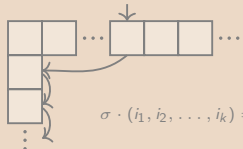
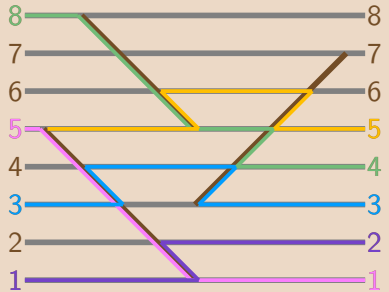
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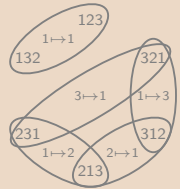


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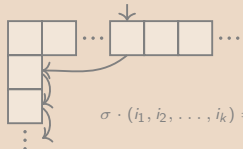
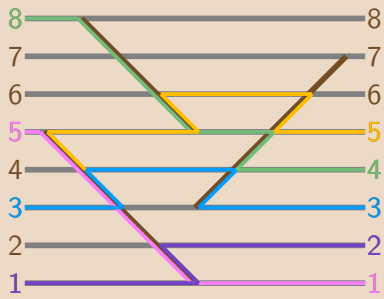


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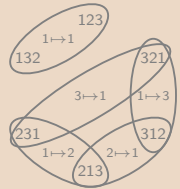




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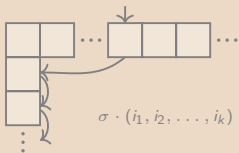
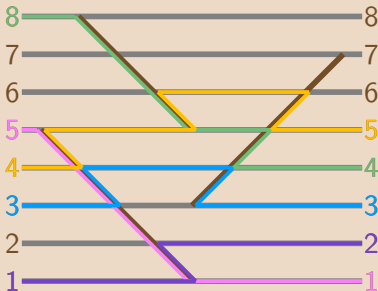


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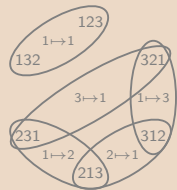




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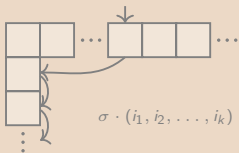
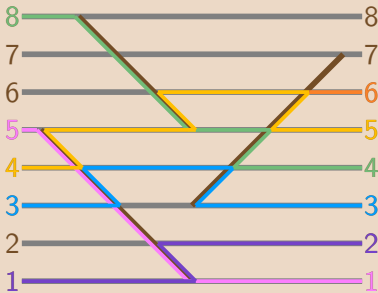


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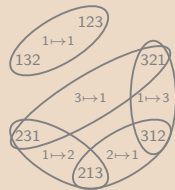




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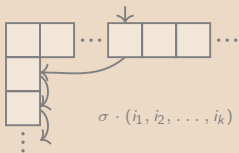
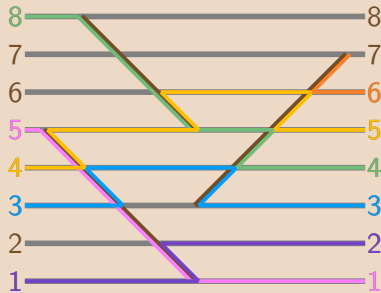


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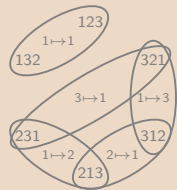




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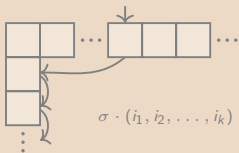
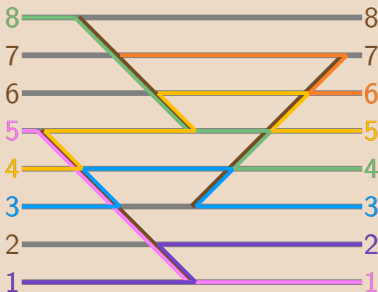


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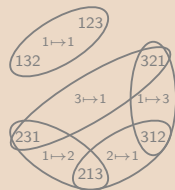




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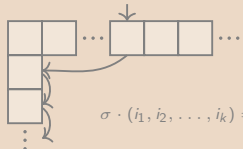
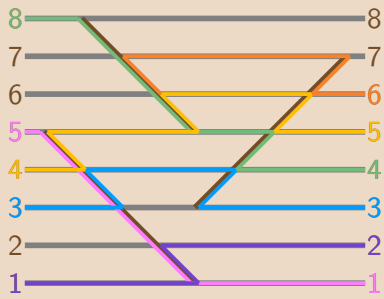
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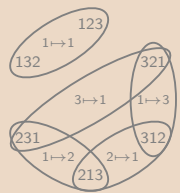




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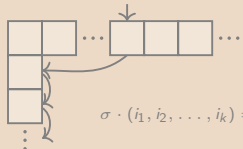
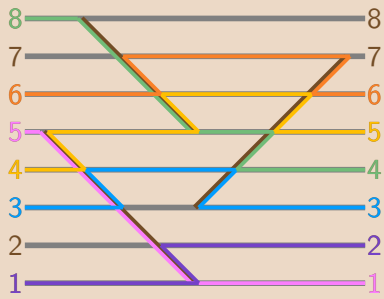
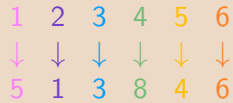


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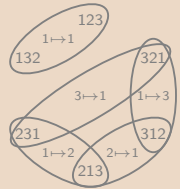




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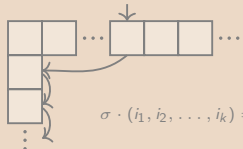
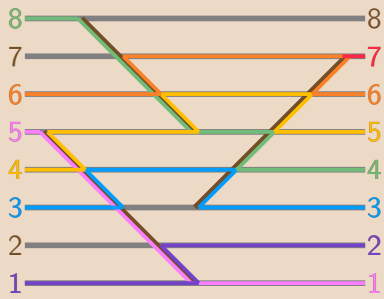


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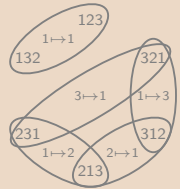




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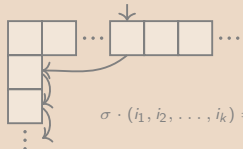
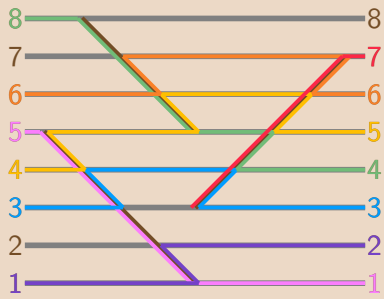
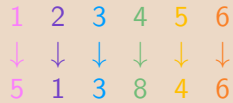


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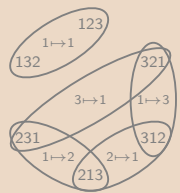




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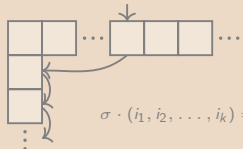
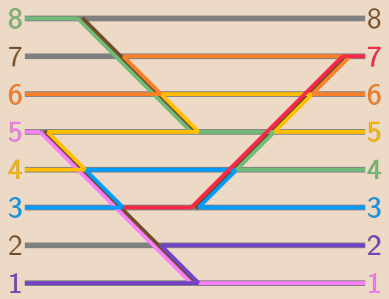
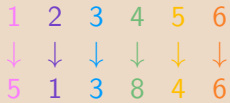


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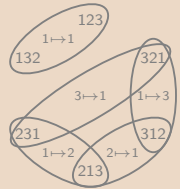




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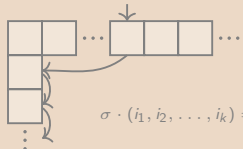
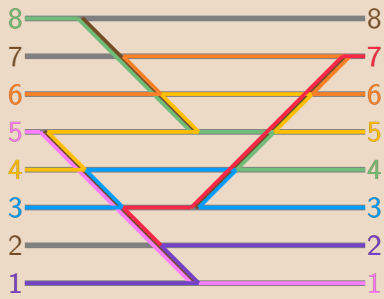
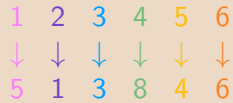


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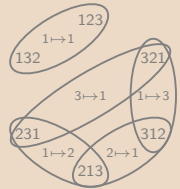




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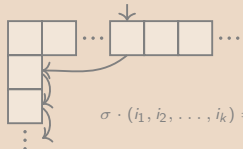
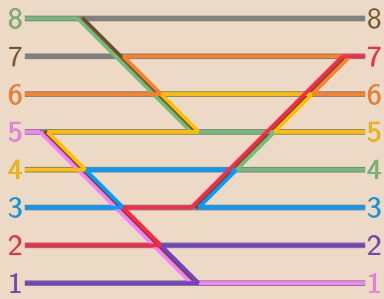


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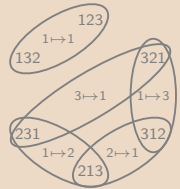




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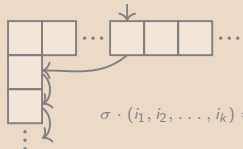
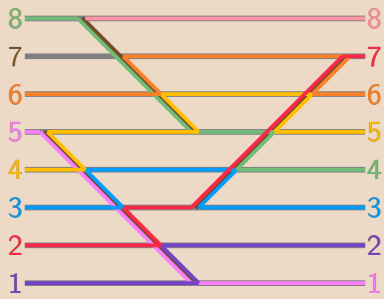


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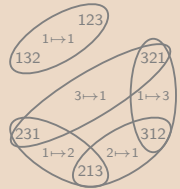




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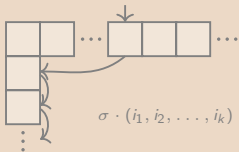
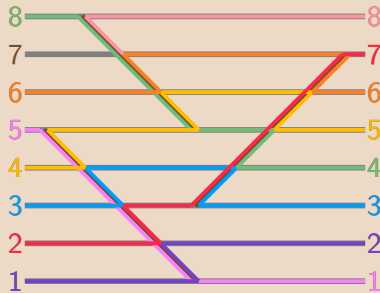
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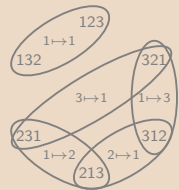




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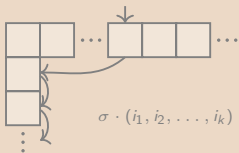
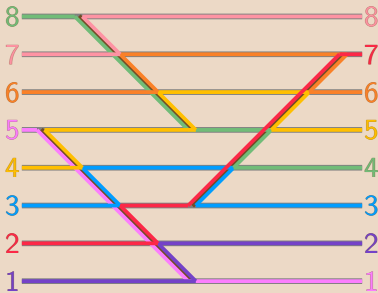


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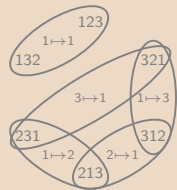




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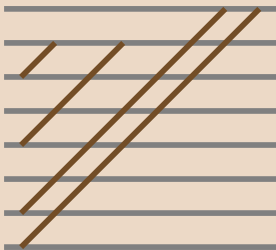
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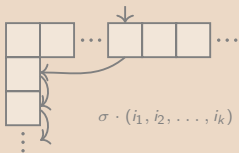
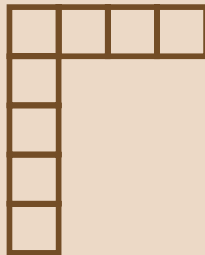


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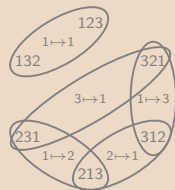
Reduced Words



RSK Tableaux



$$\sigma \cdot (i_1, i_2, \dots, i_k) = (\sigma(i_1), \sigma(i_2), \dots, \sigma(i_k))$$

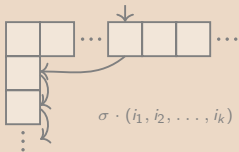




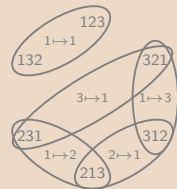
$$\mathbb{C}\mathfrak{S}_n \cong \bigoplus_{\lambda \vdash n} M^{f^\lambda} \times f^\lambda$$

5 1 3 8 4 6 2 7

1 2 3 4 5 6 7 8



$$\sigma \cdot (i_1, i_2, \dots, i_k) = (\sigma(i_1), \sigma(i_2), \dots, \sigma(i_k))$$





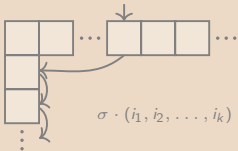
$$\mathbb{C}\mathfrak{S}_n \cong \bigoplus_{\lambda \vdash n} M^{f^\lambda} \times f^\lambda$$

↓  
5 1 3 8 4 6 2 7

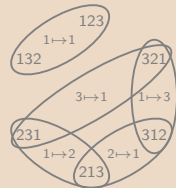
↓  
1 2 3 4 5 6 7 8

5

1



$$\sigma \cdot (i_1, i_2, \dots, i_k) = (\sigma(i_1), \sigma(i_2), \dots, \sigma(i_k))$$





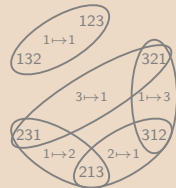
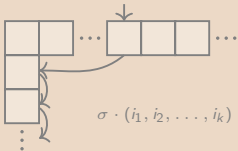
$$\mathbb{C}\mathfrak{S}_n \cong \bigoplus_{\lambda \vdash n} M^{f^\lambda} \times f^\lambda$$

$\downarrow$   
 5 1 3 8 4 6 2 7

$\downarrow$   
 1 2 3 4 5 6 7 8

1  
5

1  
2





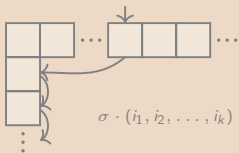
$$\mathbb{C}\mathfrak{S}_n \cong \bigoplus_{\lambda \vdash n} M^{f^\lambda} \times f^\lambda$$

5 1 3 8 4 6 2 7

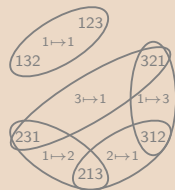
1 2 3 4 5 6 7 8

1 3  
5

1 3  
2



$$\sigma \cdot (i_1, i_2, \dots, i_k) = (\sigma(i_1), \sigma(i_2), \dots, \sigma(i_k))$$









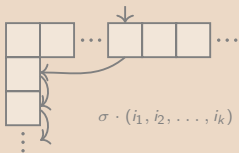
$$\mathbb{C}\mathfrak{S}_n \cong \bigoplus_{\lambda \vdash n} M^{f^\lambda} \times f^\lambda$$

5 1 3 8 4 6 2 7

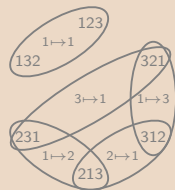
1 2 3 4 5 6 7 8

1 3 4  
5 8

1 3 4  
2 5



$$\sigma \cdot (i_1, i_2, \dots, i_k) = (\sigma(i_1), \sigma(i_2), \dots, \sigma(i_k))$$





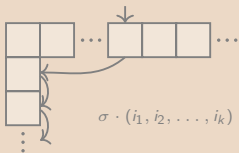
$$\mathbb{C}\mathfrak{S}_n \cong \bigoplus_{\lambda \vdash n} M^{f^\lambda} \times f^\lambda$$

5 1 3 8 4 6 2 7

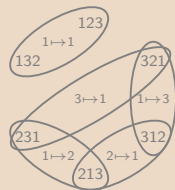
1 2 3 4 5 6 7 8

1 3 4 6  
5 8

1 3 4 6  
2 5



$$\sigma \cdot (i_1, i_2, \dots, i_k) = (\sigma(i_1), \sigma(i_2), \dots, \sigma(i_k))$$





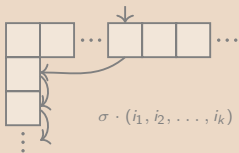
$$\mathbb{C}\mathfrak{S}_n \cong \bigoplus_{\lambda \vdash n} M^{f^\lambda} \times f^\lambda$$

5 1 3 8 4 6 2 7

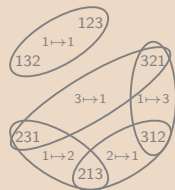
1 2 3 4 5 6 7 8

1 2 4 6  
3 8  
5

1 3 4 6  
2 5  
7



$$\sigma \cdot (i_1, i_2, \dots, i_k) = (\sigma(i_1), \sigma(i_2), \dots, \sigma(i_k))$$





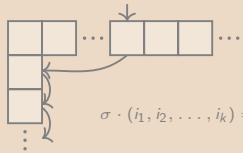
$$\mathbb{C}\mathfrak{S}_n \cong \bigoplus_{\lambda \vdash n} M^{f^\lambda} \times f^\lambda$$

5 1 3 8 4 6 2 7 ↓

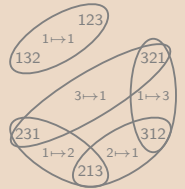
1 2 3 4 5 6 7 8 ↓

1 2 4 6 7  
3 8  
5

1 3 4 6 8  
2 5  
7



$$\sigma \cdot (i_1, i_2, \dots, i_k) = (\sigma(i_1), \sigma(i_2), \dots, \sigma(i_k))$$

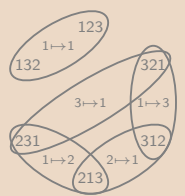
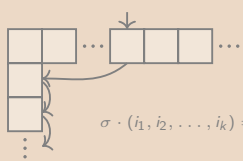
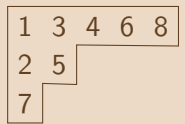
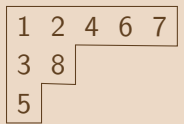




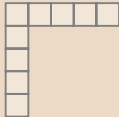
$$\mathbb{C}\mathfrak{S}_n \cong \bigoplus_{\lambda \vdash n} M^{f^\lambda} \times f^\lambda$$

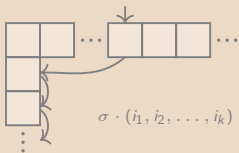
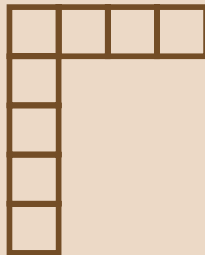
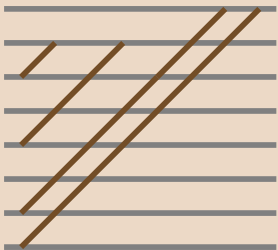
5 1 3 8 4 6 2 7

1 2 3 4 5 6 7 8

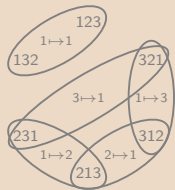




$$\mathbb{C}\mathfrak{S}_n \cong \bigoplus_{\lambda \vdash n} M^{f^\lambda} \times f^\lambda$$




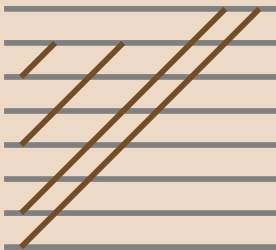
$$\sigma \cdot (i_1, i_2, \dots, i_k) = (\sigma(i_1), \sigma(i_2), \dots, \sigma(i_k))$$



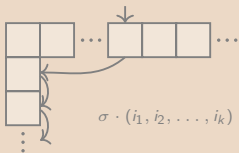
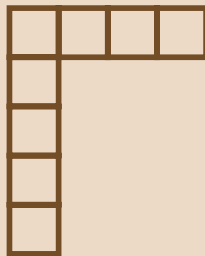


$$\mathbb{C}\mathfrak{S}_n \cong \bigoplus_{\lambda \vdash n} M^{f^\lambda} \times f^\lambda$$

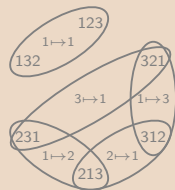
Nested



Hook-Shaped



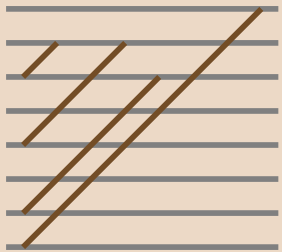
$$\sigma \cdot (i_1, i_2, \dots, i_k) = (\sigma(i_1), \sigma(i_2), \dots, \sigma(i_k))$$



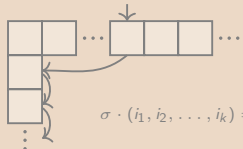
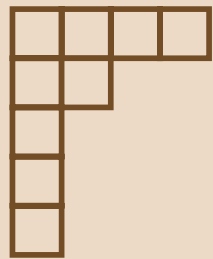


$$\mathbb{C}\mathfrak{S}_n \cong \bigoplus_{\lambda \vdash n} M^{f^\lambda} \times f^\lambda$$

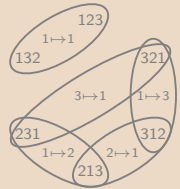
Not Nested



Not Hook-Shaped



$$\sigma \cdot (i_1, i_2, \dots, i_k) = (\sigma(i_1), \sigma(i_2), \dots, \sigma(i_k))$$

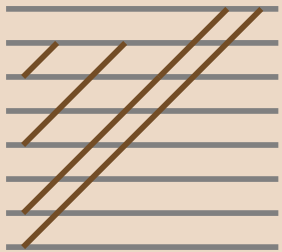




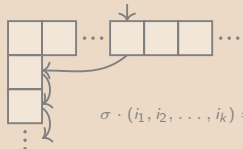
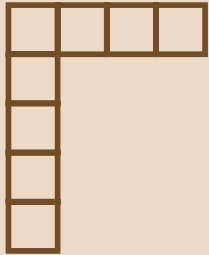


$$\mathbb{C}\mathfrak{S}_n \cong \bigoplus_{\lambda \vdash n} M^{f^\lambda} \times f^\lambda$$

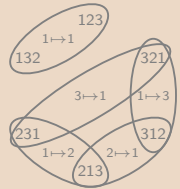
Nested



Hook-Shaped

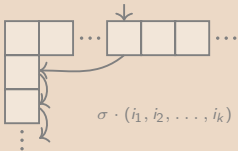
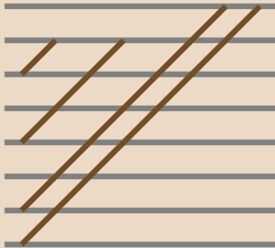


$$\sigma \cdot (i_1, i_2, \dots, i_k) = (\sigma(i_1), \sigma(i_2), \dots, \sigma(i_k))$$

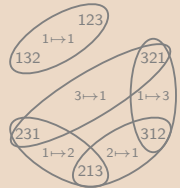




$$\mathbb{C}\mathfrak{S}_n \cong \bigoplus_{\lambda \vdash n} M^{f^\lambda} \times f^\lambda$$

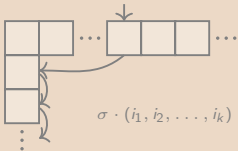
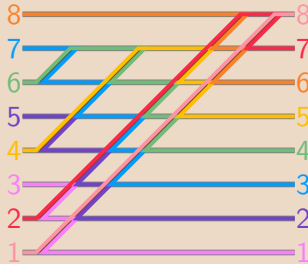


$$\sigma \cdot (i_1, i_2, \dots, i_k) = (\sigma(i_1), \sigma(i_2), \dots, \sigma(i_k))$$

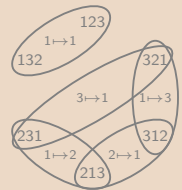




$$\mathbb{C}\mathfrak{S}_n \cong \bigoplus_{\lambda \vdash n} M^{f^\lambda} \times f^\lambda$$

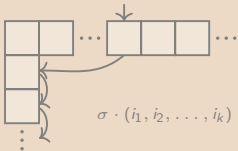
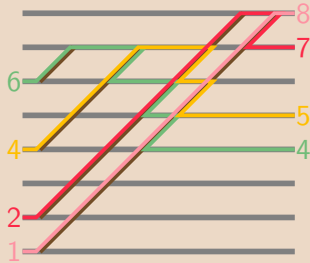


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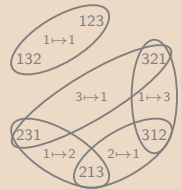




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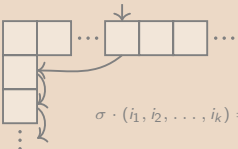
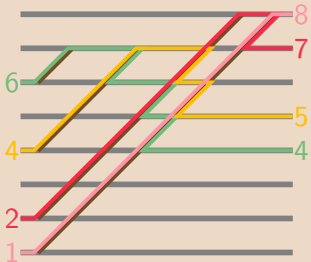


$$\sigma \cdot (i_1, i_2, \dots, i_k) = (\sigma(i_1), \sigma(i_2), \dots, \sigma(i_k))$$

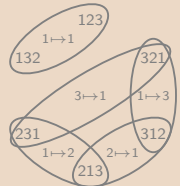




$$\mathbb{C}\mathfrak{S}_n \cong \bigoplus_{\lambda \vdash n} M^{f^\lambda} \times f^\lambda$$



$$\sigma \cdot (i_1, i_2, \dots, i_k) = (\sigma(i_1), \sigma(i_2), \dots, \sigma(i_k))$$





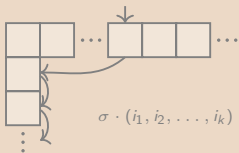
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Thank you!



Special thanks to my advisors, Professors Michael Orrison and Peter Kagey, my senior thesis class, and the Harvey Mudd Math Department!



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