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Counting Permutations by Congruence Class of Major Index

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Let S_n be the symmetric group of all permutations of $\{1, 2, ..., n\}$. A permutation $\pi = a_1 a_2 ... a_n$ in S_n (written in oneline form) has major index

 $maj \ \pi = Sum_{a < sub > i} > a_{i+1} < /sub > i,$

i.e., maj π is the sum of all the indices i where π has a descent. The major index is an important statistic in combinatorics and has many interesting properties.

Now fix two positive integers k, I which are relatively prime (i.e., have no common factors) and are at most n. Let $m_n^{k,l}$ be the k×l matrix whose (i,j) entry is the cardinality of the set

 $\{\pi \text{ in } S_n : maj \ \pi = i \ (mod \ k) \text{ and } maj \ \pi^{\cdot 1} = j \ (mod \ l) \}.$

Surprisingly, this matrix has all its entries equal! We will outline a combinatorial proof of this theorem and other related results.

This is joint work with Helene Barcelo and Sheila Sundaram.

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