# Generating permutations

- **Decrease-by-one technique**
  - assume we have all $(n-1)!$ permutations
  - insert $n$ into each of the $n$ positions of every permutation of $n-1$ elements

example

$n=2$ 12 21

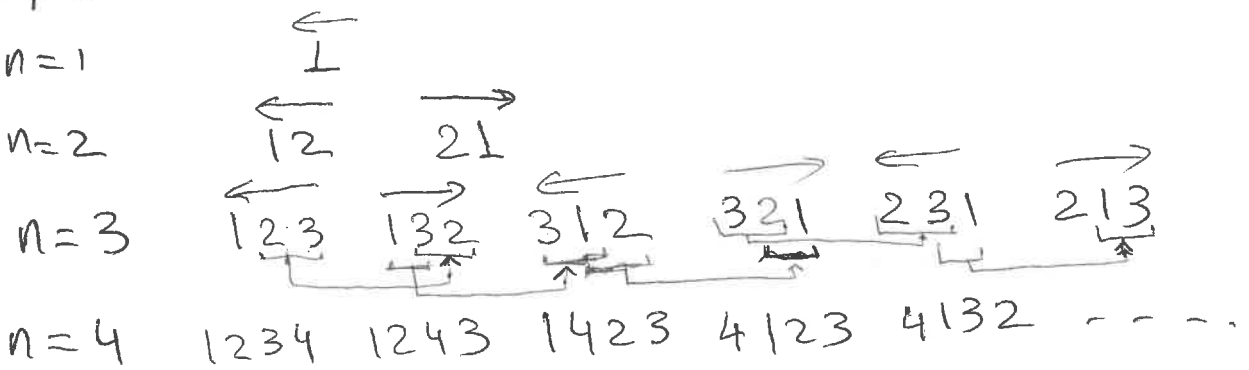
$n=3$ 312 132 123 321 231 213

- **Bottom-up minimal-change algorithm**

  each permutation can be obtained from its predecessor by exchanging 2 elements

  - insert $n$ into $12\ldots(n-1)$ by moving right-to-left, then switch direction each time a new permutation $\{1,2,\ldots,n-1\}$ is processed

example




- **Johnson-Trotter algorithm**
  - each iteration:
    - find largest mobile element $k$
    - swap $k$ with adjacent element using $k$'s direction
    - reverse direction for element greater than $k$

example

$n=3$