We may collect the results as follows.

SUMMARY. Let $G = \langle \sigma, \tau \rangle$ with $\sigma, \tau \in \mathrm{Sym}(n)$ and τ a transposition.

1. If σ is an n-cycle, the G is described in Theorem 3.
2. If σ is a product of disjoint cycles, one of which moves both the symbols moved by τ, then G is described in Theorem 5.
3. If σ fixes both symbols moved by τ then $G = \langle \sigma \rangle \times \langle \tau \rangle$ is an abelian group.
4. If σ moves one, but not both of, the symbols moved by τ or if σ moves both symbols moved by τ but not in the same cycle then σ may be replaced by $\sigma_1 = \tau\sigma$ and then $G = \langle \sigma_1, \tau \rangle$ and G is described as in case 1 or 2.

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