Let $E$ be an optimal elliptic curve defined over $\mathbb{Q}$. The critical subgroup of $E$ is defined by Mazur and Swinnerton-Dyer as the subgroup of $E(\mathbb{Q})$ generated by traces of branch points under a modular parametrization of $E$. We prove that for all rank two elliptic curves with conductor smaller than 1000, the critical subgroup has rank zero. First, we define a family of critical polynomials attached to $E$ and describe how to compute such polynomials. We then give conditions for the critical subgroup to be torsion in terms of the factorization of critical polynomials. Finally, a table of critical polynomials is obtained for all elliptic curves of rank two and conductor smaller than 1000, from which we deduce our result. (Received February 12, 2015)