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On edge orbits and hypergraph designs

Let $\mathbb{Z}_n$ denote the group of integers modulo n and let $\mathcal{E}_n^{(k)}$ be the set of all k-element subsets of $\mathbb{Z}_n$ where $1 \leq k < n$. If $E \in \mathcal{E}_n^{(k)}$, let $[E] = \{E + r : r \in \mathbb{Z}_n\}$. Then $[E]$ is the orbit of E where $\mathbb{Z}_n$ acts on $\mathcal{E}_n^{(k)}$ via $(r, E) \mapsto E + r$. Furthermore, $\{[E] : E \in \mathcal{E}_n^{(k)}\}$ is a partition of $\mathcal{E}_n^{(k)}$ into $\mathbb{Z}_n$-orbits. We count the number of $\mathbb{Z}_n$-orbits in $\mathcal{E}_n^{(k)}$ and give the corresponding results when fixed points are introduced. We also give applications to cyclic and r-pyramidal decompositions of certain classes of uniform hypergraphs into isomorphic subgraphs.