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On a Free-Endpoint Isoperimetric Problem in $\mathbb{R}^2$

Inspired by a mixed planar partitioning problem, we investigate using classical techniques what can be said of the existence, uniqueness, and regularity of minimizers in a certain free-endpoint isoperimetric problem. By restricting to curves which are expressible as graphs of functions, we prove a full existence-uniqueness-regularity result using a convexity technique inspired by work of Talenti. The problem studied here can be interpreted physically as the identification of the equilibrium shape of a sessile liquid drop in half-space (in the absence of gravity). This is a well-studied variational problem whose full resolution requires the use of geometric measure theory, in particular the theory of sets of finite perimeter, but here we use a more direct, classical geometrical approach. We present conjectures on other mixed planar partitioning problems throughout.