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Scaling Relations for Wheeled Locomotion in Granular Media
JAMES SLONAKER, KEN KAMRIN, MIT — Vehicular wheel design for use on granular material has not currently been perfected. Resistive Force Theory (RFT) is a reduced-order empirical model for granular drag, which shows promise to help simulate and understand locomotion processes to design more efficient wheels. Here we explore the fundamental scaling relations derived from RFT and their experimental validation. Similar to the non-dimensional scaling relations in fluid mechanics, the relative simplicity of RFT asserts that only one material parameter, the "grain-structure coefficient", is required, which reduces the complexity of the non-dimensional groups implied by the system. Therefore, wheels with differing input design parameters like size, mass, shape and even gravity, can be tested and their performance related to each other in predictable ways. We experimentally confirmed these relations by testing with 3D printed wheel geometries in a controlled sand bed.

James Slonaker
MIT

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