# Silo outflow of soft frictionless spheres

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## Abstract

Outflow of granular materials from silos is a remarkably complex physical phenomenon
that has been extensively studied with simple objects like monodisperse hard disks in two
dimensions (2D) and hard spheres in 2D and 3D. For those materials, empirical equations
were found that describe the discharge characteristics. Softness adds qualitatively new
features to the dynamics and to the character of the flow.We report a study of the outflow of
soft, practically frictionless hydrogel spheres from a quasi-2D bin. Prominent features are
intermittent clogs, peculiar flow fields in the container, and a pronounced dependence of the
flow rate and clogging statistics on the container fill height. The latter is a consequence of
the ineffectiveness of Janssen's law: the pressure at the bottom of a bin containing hydrogel
spheres grows linearly with the fill height.

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