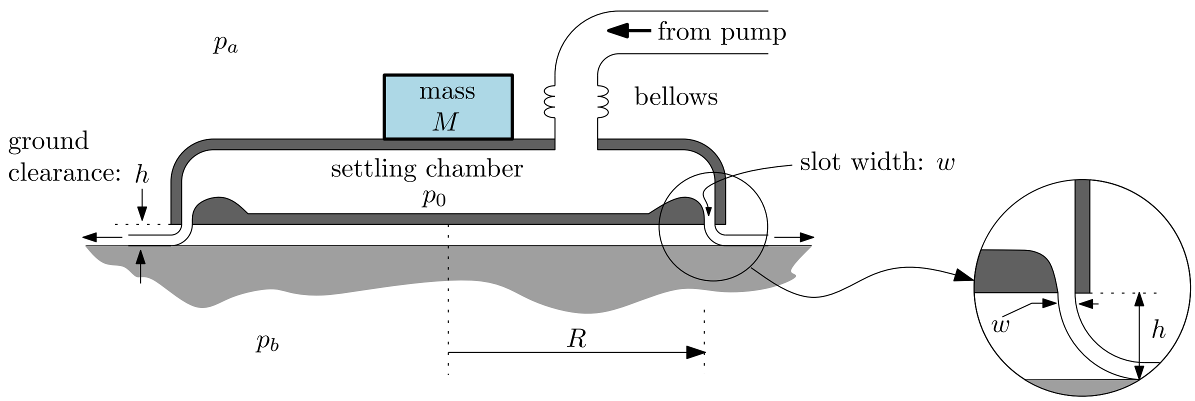
MIT Department of Mechanical Engineering
2.25 Advanced Fluid Mechanics

Problem 4.19
This problem is from "Advanced Fluid Mechanics Problems" by A.H. Shapiro and A.A. Sonin



A circular hovering platform of radius R is to support a mass M (its own mass plus a load). A thin, sheet-like jet (width w) is directed downward at the platform's periphery, as shown. The jet is fed from a settling chamber which is maintained at a pressure p_0 by an external pump. The system is to hover at an elevation h which is large compared to the width w of the sheet-like jet, but small compared with R.

When the jet is turned on, the pressure under the platform builds up and the platform rises until a steady state is reached. It is this steady state that we are concerned with.

(a) Describe the physical mechanism which allows the pressure p_b under the platform be higher than the atmospheric pressure p_a, in steady state, and thus to support a weight

$$Mg = (p_b - p_a)\,\pi R^2$$

(b) Given the system weight Mg, the platform radius R, the jet width w, and the air density ρ, derive approximate expressions for (i) the volume flow rate Q of air required and (ii) the gage pressure p_0 required in the settling chamber, in order to maintain a ground clearance h. You may assume incompressible, inviscid flow in the peripheral jet, and make physical approximations consistent with the jet being thin compare with h ($w \ll h$) and the gage pressure $p_b - p_a$ below the platform being very small compared with the gage pressure $p_0 - p_a$ in the settling chamber.