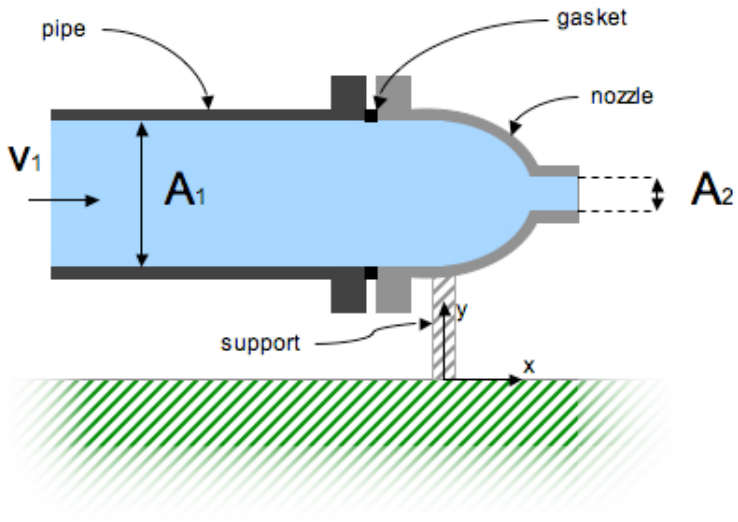
MIT Department of Mechanical Engineering
2.25 Advanced Fluid Mechanics

Problem 5.02
This problem is from "Advanced Fluid Mechanics Problems" by A.H. Shapiro and A.A. Sonin



A pipe of area A_1 carries a gas at density ρ and velocity V_1. A converging nozzle is mounted at the end of the pipe, as shown, to increase the gas velocity as it emerges into the atmosphere. The flow in the nozzle is incompressible.

- (a) Use the momentum theorem to derive the x and y components of force, in excess of those required to support weight, exerted by the nozzle on its support.
- (b) What gage pressure will the presence of the nozzle induce at the pipe (where the area is A_1)?) You may model the velocity at station (1) as being uniform and assume that the velocity is also uniform at (2). As regards part (a), there is clearly ambiguity in the problem as being stated, since the x component of the force on the support will depend on the compression force applied to the gasket, as well as on the fluid flow. In answering (a), consider just the flow-induced force which will be exerted when the compression force on the gasket is zero.
- (c) Apart from the assumption that conditions at (2) have attained uniformity, does the result in (a) depend in any way on the contour of the nozzle between (1) and (2)?
- (d) What is the direction of the force (a) if $A_2 < A_1$? If $A_2 > A_1$? Explain.

Note: See also problem 4.4.

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