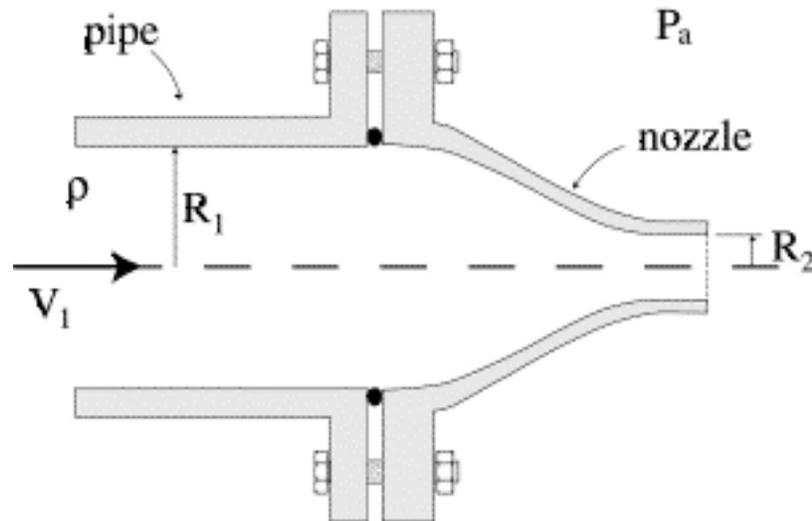


Problem 5.1

Force on nozzle

Ain Sonin



A circular pipe with radius R_1 carries a fluid with density ρ to a converging nozzle with exit radius R_2 , mounted at its end. Before the flow is started, the bolts that compress the nozzle against pipe flange (see the figure) are tightened until the collective tensile force on them is F_B . The gasket provides a leak-proof seal. A steady flow is then established with a velocity V_1 at the entrance to the nozzle (station 1). The ambient pressure is p_a . It is agreed that the flow in the nozzle may be considered *incompressible* (the Mach number is small) and *inviscid* (the Reynolds number large).

- (a) What gage pressure will the flow induce at station 1?
HINT ANSWER
- (b) Use the momentum theorem to derive the additional tensile force F exerted on the bolts after the flow is started.
HINT HINT 2 ANSWER
- (c) Apart from the assumption that the velocity at stations 1 and 2 is uniform, does the result in (a) depend in any way on the contour of the nozzle between the two stations?
- (d) What is the sign of the additional force F (positive or negative?) if $R_2 < R_1$? If $R_2 > R_1$? Explain.
ANSWER