FLUID MECHANICS D209 Q3 1996

A horizontal nozzle of diameter 20 mm is located at the end of a pipe 30 mm diameter. Water discharges to atmosphere at a rate of 2.5 dm^3/s as shown. There is no energy loss or contraction.

a) determine the force on the nozzle.
b) The jet strikes a flat plate as shown as flows off the plate at right angles to the jet.
Calculate the force on the plate if it is stationary.
Calculate the force on the plate if it moves at 5 m/s
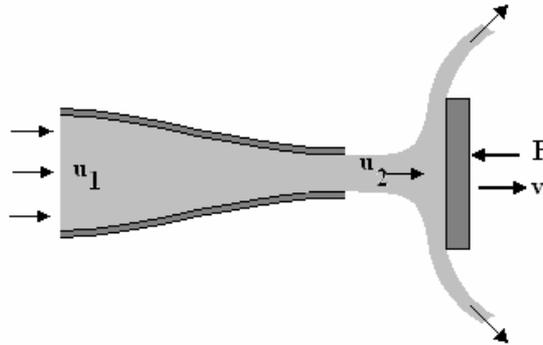
Inlet to nozzle $u_1 = Q/A_1 = 2.5$ x 10^{-3} x $/\pi$ x $0.03^2 = 3.537$ m/s
Exit from nozzle $u_2 = Q/A_2 = 2.5$ x 10^{-3} x $/\pi$ x $0.02^2 = 7.96$ m/s
Bernoulli Use gauge pressures and $p_2 = 0$

$p_1 + \rho u_1^2/2 = p_2 + \rho u_2^2/2$
$p_1 = 0 + (\rho/2)(u_2^2 - u_1^2) = 500(7.96^2 - 3.537^2) = 25415$ N/m^2

Force Balance
$p_1A_1 + mu_1 = p_2A_2 + mu_2 + F$ $m = 2.5$ kg/s
$25415 A_1 + m(u_1 - u_2) = F$
25415x π x $0.03^2/4 + 2.5(3.537 - 7.96) = F$
$17.96 - 11 = F = 6.96$ N   THIS IS THE FORCE ON THE NOZZLE.

STATIONARY VANE

$F = m \Delta U = 2.5(7.96 - 0) = 20$ N   in the direction of the jet.

MOVING VANE

Mass striking the vane $= \rho A_2(u_2 - v)$

$F = m (u - v) = \rho A_2(u_2 - v) (u - v) = \rho A_2(u_2 - v)^2$

$F= 1000$ x $(\pi$ x $0.02^2/4)$ $(7.96 - 5)^2 = 11.16$ N in the direction of the jet.