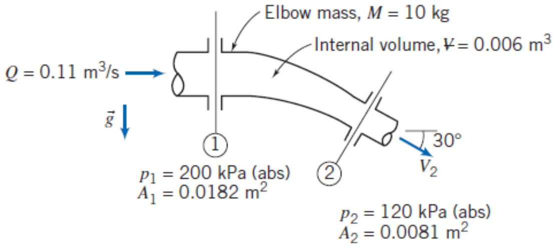
MIC-205: Fluid Mechanics

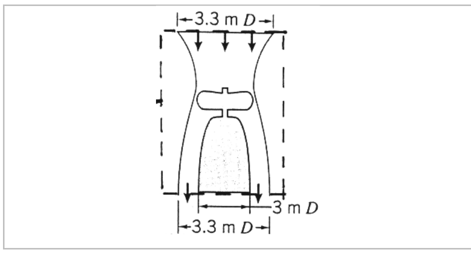
Tutorial 7: Dynamics, Navier Stokes Equation, Bernoulli's Equation

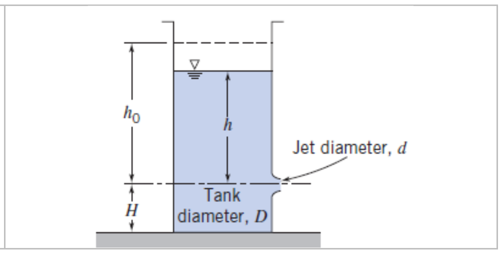
Semester: Autumn 2024-25

Problem 1: A reducing elbow is shown. The fluid is water. Evaluate the components of force that must be provided by the adjacent pipes to keep the elbow from moving. [-1040, -667] N



Problem 2: The total mass of the helicopter-type craft shown is 1000 kg. The pressure of the air is atmospheric at the outlet. Assume the flow to be steady, incompressible and one-dimensional , calculate the speed of air leaving the craft and minimum power delivered to air by the propeller.

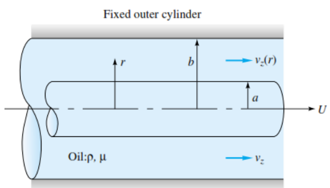




Problem 3: The tank, of diameter D, has a well-rounded nozzle with diameter d. At t=0, the water level is at height h_0. Develop an expression for dimensionless water height, h/h_0 as function of time.

Problem 4: Oil flows steadily between two concentric cylinders due to the axial motion of the inner cylinder. The inner cylinder moves axially at velocity U while the outer cylinder is fixed. The radius of inner and outer cylinder are **a** and **b**, respectively. Assuming a fully developed, axisymmetric, incompressible flow, determine the axial component of velocity of fluid u_z (r).

Ans: $\boldsymbol{u_z(r) = \frac{ln\left(^{r}/_{b}\right)}{ln\left(^{a}/_{b}\right)}}$



Problem 5: A viscous, incompressible, Newtonian liquid flows in steady, laminar flow down a vertical wall. The thickness, δ, of the liquid film is constant. There is no pressure gradient since the liquid-free surface is exposed to atmospheric pressure. Simply the Navier-Stokes equation for this gravity-driven flow and derive the velocity distribution in the liquid film.

Ans: $u(y) = \frac{\rho g}{\mu}\left(\delta y - \frac{y^2}{2}\right)$

Problem 6: Consider a steady, two-dimensional, incompressible inviscid flow of a fluid with the velocity field $u = -2xy$, $v = y^2 - x^2$, and $w = 0$. Find the pressure field $p(x, y)$ if the pressure at the point (x = 0, y = 0) is equal to p_a.

Problem 7: Consider 2-D incompressible steady flow between parallel plates with the upper plate moving at speed **V**. Let the fluid be non-Newtonian, with stress given by

$$\tau_{xx} = a\left(\frac{\partial u}{\partial x}\right)^c \quad \tau_{yy} = a\left(\frac{\partial v}{\partial y}\right)^c \quad \tau_{xy} = \tau_{yx} = \frac{a}{2}\left(\frac{\partial u}{\partial y} + \frac{\partial v}{\partial x}\right)^c, \quad a \text{ and } c \text{ are constants}$$

Determine $u(y)$