Introduction to Transport Phenomena: Exercises Module 2

Exercise 2.1

(macroscopic mass balance)

Gas diffuser: Gas flows with $Q = 300\frac{L}{s}$ through a gas diffuser ($A_1 = 0.02m^2, A_2 = 0.04m^2$). The inlet pressure $p_1 = 1.25bar$ and at this pressure the gas has a density $\rho_1 = 1.17\frac{kg}{m^3}$. At the outlet of the diffuser the pressure is $p_2 = 1bar$. Estimate the average velocity $v_{2,avg}$ of the gas exiting the diffusor under assumption of a perfect gas and an isothermal system. (Note: remember that the density of gases changes with pressure)

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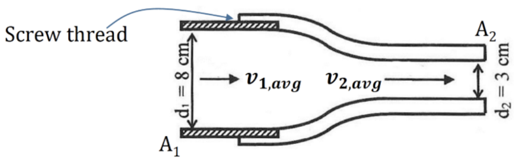
Exercise 2.2

(Bernoulli's + momentum balance)

Fire hose nozzle: The nozzle of a fire hose (inner diameter: $d_1 = 3cm$) is screwed to a cylindrical pipe of 8cm inner diameter. When the nozzle is open, the spray delivers $Q = 40\frac{L}{s}$ of water at a temperature of $20°C$. The pressure drops to the ambient pressure at the nozzle outlet. Estimate:

a) The total pressure under which the nozzle works p_1

b) The force exerted along the x-axis on the thread by the fluid



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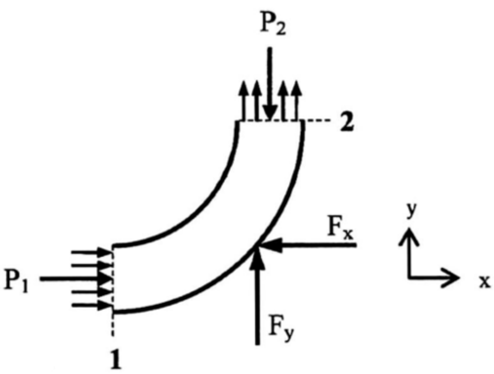
Exercise 2.3

(momentum balance)

A pipe with a diameter $d = 600mm$ carries oil with a density of $\rho = 850\frac{kg}{m^3}$ at a flow rate of $Q = 0.9\frac{m^3}{s}$. The pipe is bended 90°. The pressure drop through the pipe equals a static pressure of $1m$ of oil. The inlet pressure $p_1 = 300kPa$. Neglecting friction losses, estimate the module and the angle of force exerted on the elbow. (This is $\overrightarrow{F_{rxn}} = \overrightarrow{F_{rxn,x}} + \overrightarrow{F_{rxn,y}}$).



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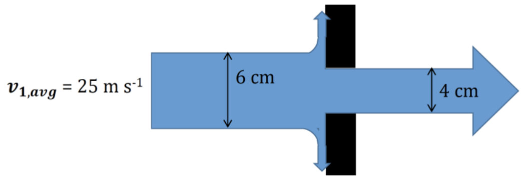
Exercise 2.4

(momentum balance)

A horizontal free water jet with a diameter of $d = 6cm$ strikes a vertical plate with a central aperture with $d_2 = 4cm$ (at $20°C$). A portion of the water jet passes through this opening, the rest is rejected aside. The velocity of the water jet is $v_{1,avr} = 25\frac{m}{s}$. Neglecting friction losses, estimate the horizontal force needed to hold the tray in place. (Note "free" water indicates that all fluids are at atmospheric pressure. We can therefore neglect pressure terms in the momentum balance)



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