Fluid mechanics

Instruction 3

Week 3

Van onderstaande vraagstukken zal tijdens de instructie er een aantal behandeld worden. Het is een goede voorbereiding er doorheen te kijken, en te proberen of je ze zelf kan oplossen.

Let op: vraagstuknummering is niet altijd uniform door de verschillende edities van ‘White’.

3.36, 3.50, 3.51, 3.73, 3.86, 3.149, 3.160, 3.170

Bron: alle opgaven komen van het boek *Fluid Mechanics* van Frank M. White (McGraw-Hill Series in Mechanical Engineering)

Massabalans

P3.36 The jet pump in Fig. P3.36 injects water at $U_1 = 40$ m/s through a 3-in-pipe and entrains a secondary flow of water $U_2 = 3$ m/s in the annular region around the small pipe. The two flows become fully mixed downstream, where U_3 is approximately constant. For steady incompressible flow, compute U_3 in m/s.

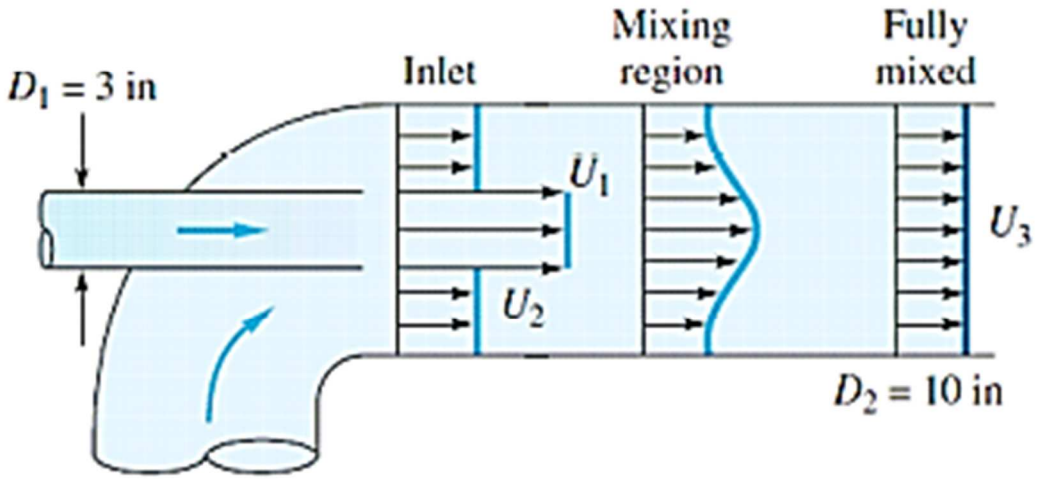
$$\alpha = A_1/A_3 = (D_1/D)^2$$

$$= (3/10)^2 = \underline{0.09}$$

$$\rightarrow U_3 = \alpha U_1 + (1-\alpha)U_2$$

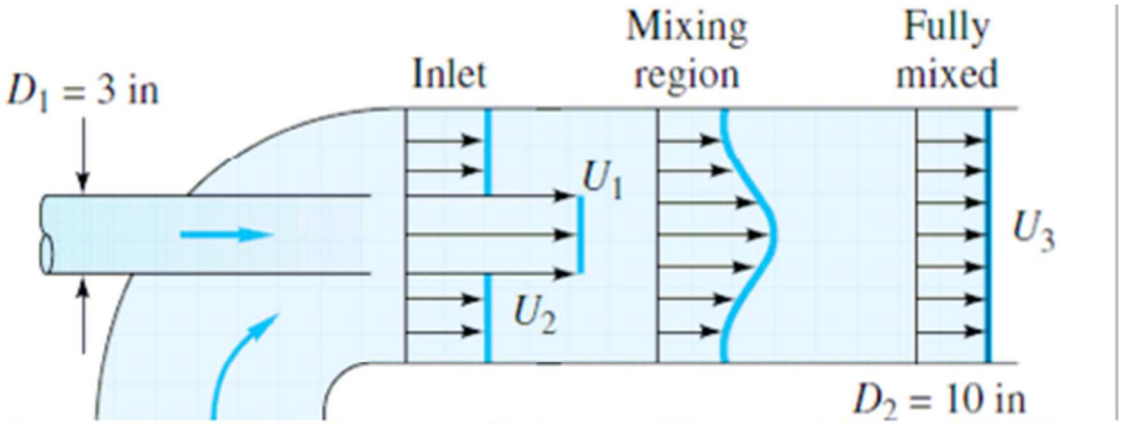
$$= 0.09*40*0.91*3$$

$$= \underline{6.33 \text{ m/s}}$$



P3.36

Impulsbalans 3.86

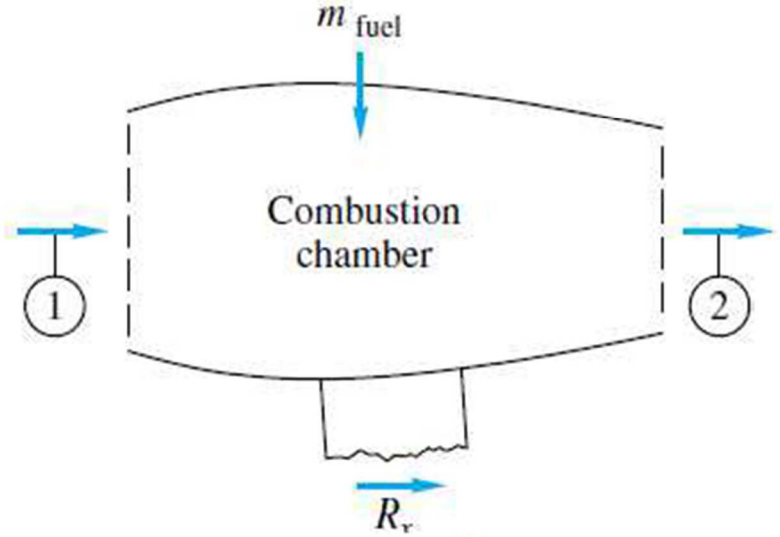


For the water-jet pump of Prob. 3.36, add the following data: $p_1 = p_2 = 25$ lbf/in^2, and the distance between sections 1 and 3 is 80 in. If the average wall shear stress between sections 1 and 3 is 7 lbf/ft^2, estimate the pressure p_3. Why is it higher than p_1?

Bedenk: 1 lbf/in2 ('psi' = veelgebruikt) = 1 pound-force per vierkente 'inch' (25.4 mm)
1 psi = 6.894×103 Pa = 0.0689 bar. Er gaan dus 14.5 psi in 1 bar.
1 lbf/ft2 = 1 pound-force per vierkente 'foot' (12 inch) = 1/144 psi = 47.9 Pa.
Industrieel helaas gebruikelijk: Druk in psi; schuifkracht in psft

Impulsbalans

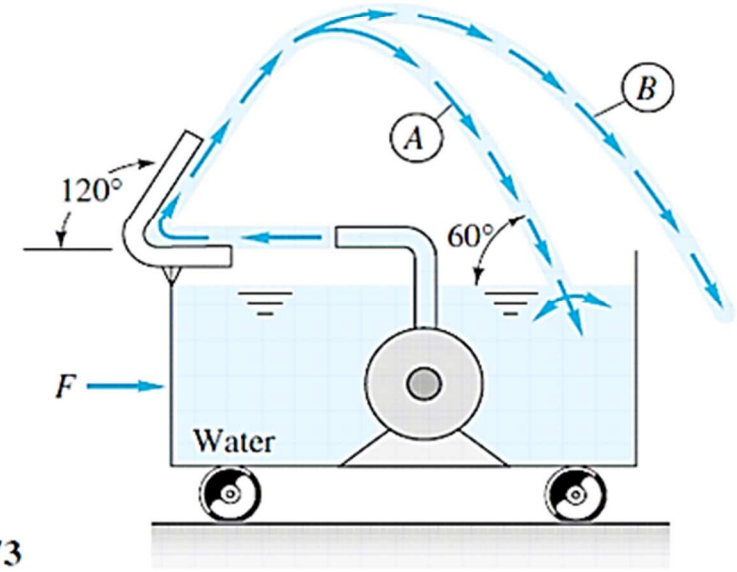
P3.50 The jet engine on a test stand in Fig. P3.50 admits air at 20°C and 1 atm at section 1, where $A_1 = 0.5$ m^2 and $V_1 = 250$ m/s. The fuel-to-air ratio is 1:30. The air leaves section 2 at atmospheric pressure and higher temperature, where $V_2 = 900$ m/s and $A_2 = 0.4$ m^2. Compute the horizontal test stand reaction R_x needed to hold this engine fixed.



P3.50

Impulsbalans

P3.73 A pump in a tank of water at 20°C directs a jet at 45 ft/s and 200 gal/min against a vane, as shown in Fig. P3.73. Compute the force F to hold the cart stationary if the jet follows (*a*) path *A* or (*b*) path *B*. The tank holds 550 gal of water at this instant.

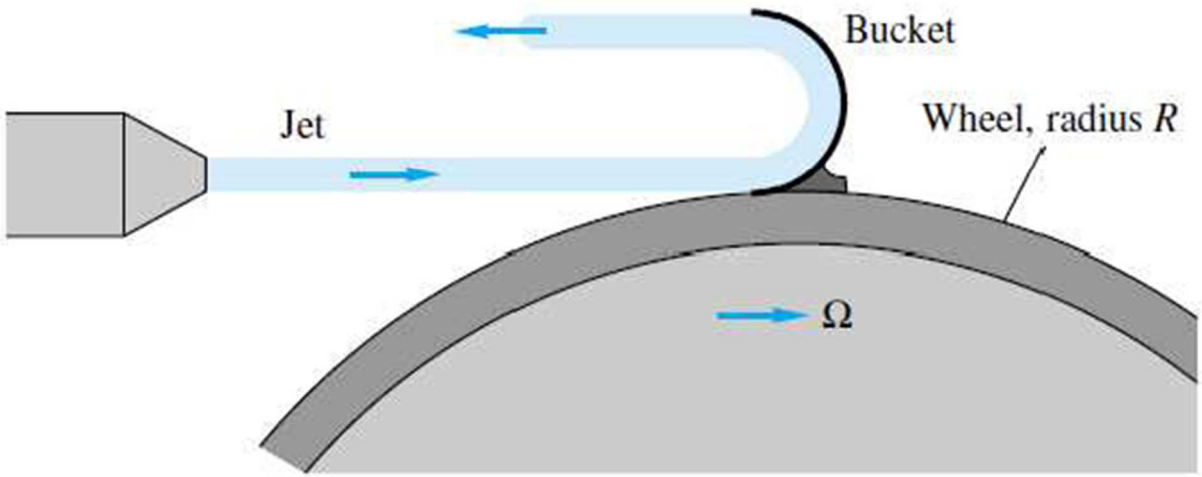


P3.73

Hoe groot is de vertikale component van de kracht bij pad B?
Hoe hangt deze af van de keuze van het CV?

Impulsbalans

P3.51 A liquid jet of velocity V_j and area A_j strikes a single 180° bucket on a turbine wheel rotating at angular velocity Ω, as in Fig. P3.51. Derive an expression for the power P delivered to this wheel at this instant as a function of the system parameters. At what angular velocity is the maximum power delivered? How would your analysis differ if there were many, many buckets on the wheel, so that the jet was continually striking at least one bucket?



Massa- en impulsbalans

Een turbulente stroming in een ronde buis van straal R kan worden beschreven met het volgende snelheidsprofiel in de buis (we zullen dit in de stromingsleer vaker tegenkomen):

, waarbij U_C de 'centreline' snelheid (dus in het midden van de buis) is.

- Maak een schets van dit snelheidsprofiel. $u(r) = U_c \cdot \left(1 - \left(r/R\right)\right)^{1/7}$
- Bepaal de gemiddelde snelheid in de buis, U, en de verhouding U_C/U.

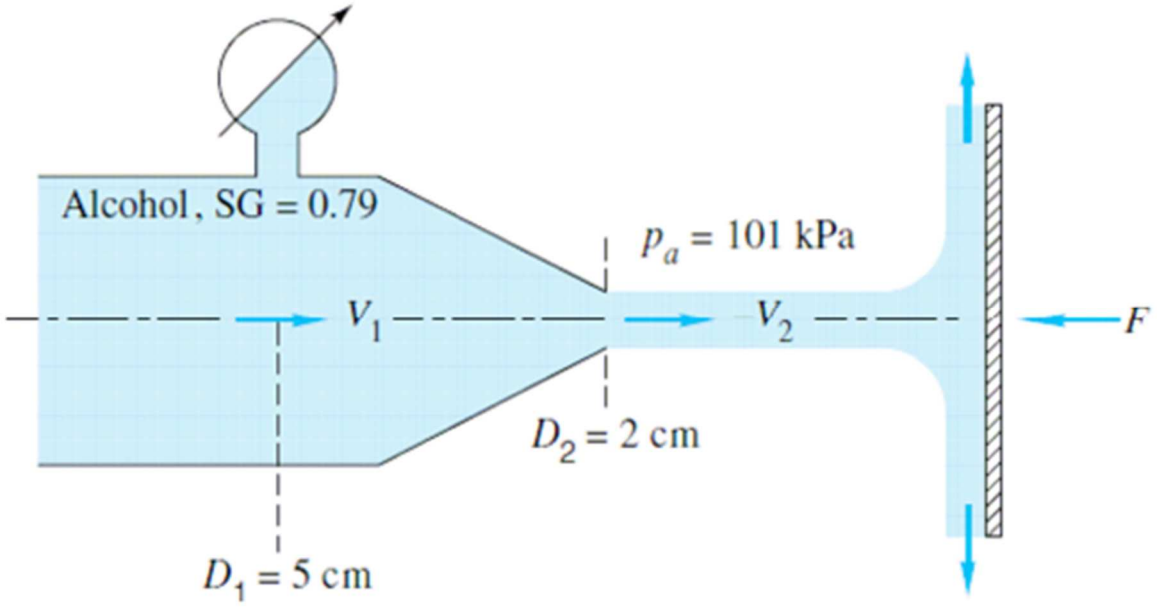
Een veelgebruikte ingenieursregel voor meten van snelheid in pijpleidingen is: 'meet op een kwart radius vanaf de wand'. Laat zien dat je hier inderdaad dicht bij de gemiddelde snelheid zit!

- Bepaal de impulsflux I door een doorsnede (een vlakje loodrecht op de buisas), en bepaal de verhouding . $I/\left(\rho U^2 \cdot \pi r^2\right)$

Deze is voor elk niet-vlak snelheidsprofiel net iets groter dan 1, en wordt in impulsbalansen soms als een 'correctiefactor' gebruikt.

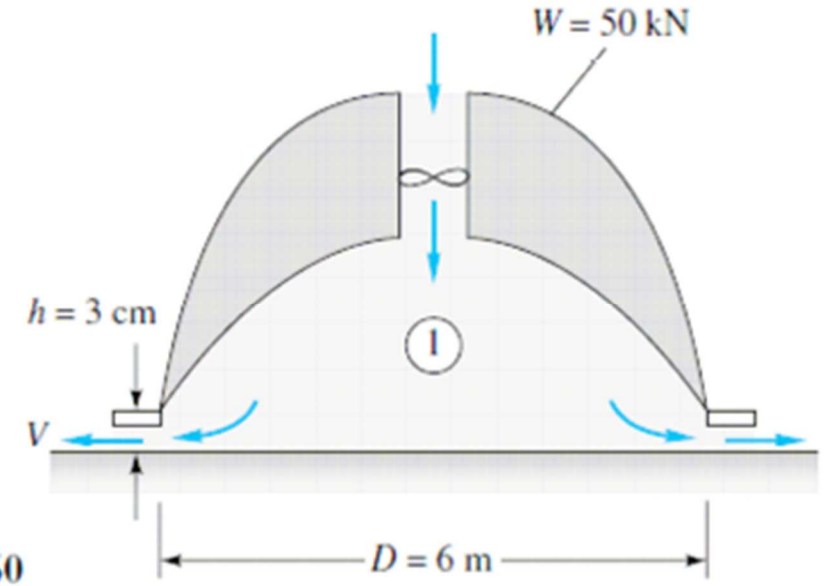
Energiebalans

P3.149 A jet of alcohol strikes the vertical plate in Fig. P3.149. A force $F \approx 425$ N is required to hold the plate stationary. Assuming there are no losses in the nozzle, estimate (*a*) the mass flow rate of alcohol and (*b*) the absolute pressure at section 1.



Energiebalans

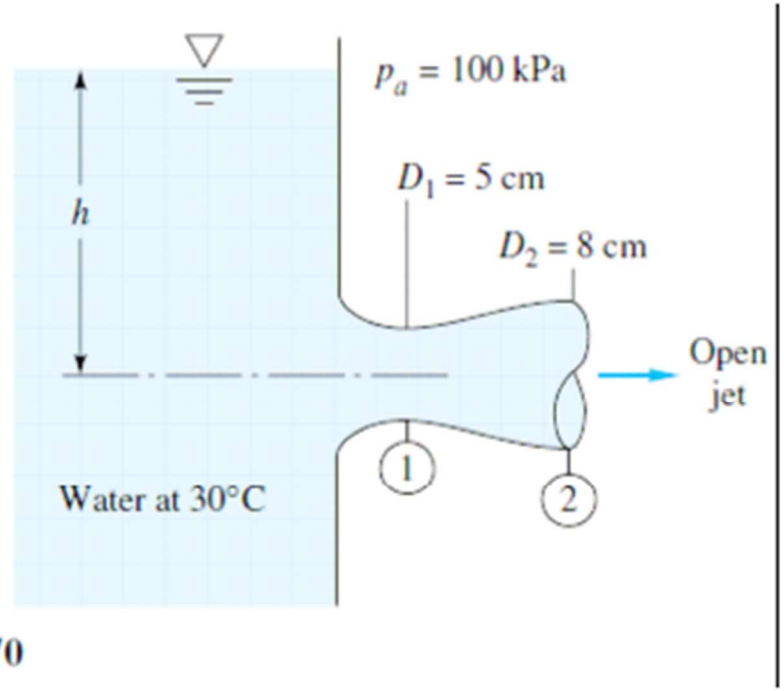
P3.160 The air-cushion vehicle in Fig. P3.160 brings in sea-level standard air through a fan and discharges it at high velocity through an annular skirt of 3-cm clearance. If the vehicle weighs 50 kN, estimate (*a*) the required airflow rate and (*b*) the fan power in kW.



P3.160

Energiebalans

P3.170 If losses are neglected in Fig. P3.170, for what water level h will the flow begin to form vapor cavities at the throat of the nozzle?



P3.170