6.4.1: Qualitative Questions

Example 6.10

For each following figures discuss and state force direction and the momentum that act on the control volume due to.

Example 6.11

*Flow Out of un Symmetrical Tank*

*Fig. 6.11 Flow out of un symmetrical tank for example*

A similar tank as shown in Figure is built with a exit located in uneven distance from the the right and the left and is filled with liquid. The exit is located on the left hand side at the front. What are the direction of the forces that keep the control volume in the same location? Hints, consider the unsteady effects. Look at the directions which the unsteady state momentum in the tank change its value.

Example 6.12

A large tank has opening with area, A. In front and against the opening there a block with mass of 50[kg]. The friction factor between the block and surface is 0.5. Assume that resistance between the air and the water jet is negligible. Calculated the minimum height of the liquid in the tank in order to start to have the block moving?

Solution 6.12

The solution of this kind problem first requires to know at what accuracy this solution is needed. For great accuracy, the effect minor loss or the loss in the tank opening have taken into account. First assuming that a minimum accuracy therefore the information was given on the tank that it large. First, the velocity to move the block can be obtained from
the analysis of the block free body diagram (the impinging jet diagram).

\[ F = \rho A(U_{exit})^2 \tag{86} \]

The minimum force the push the block is

\[ \rho A(U_{exit})^2 = m g \mu \Longrightarrow U_{exit} = \sqrt{\frac{m g \mu}{\rho A}} \tag{87} \]

And the velocity as a function of the height is \( U = \sqrt{\rho g h} \) and thus

\[ h = \frac{m \mu}{\rho^2 A} \tag{88} \]

It is interesting to point out that the gravity is relevant. That is the gravity has no effect on the velocity (height) required to move the block. However, if the gravity was in the opposite direction, no matter what the height will be the block will not move (neglecting other minor effects). So, the gravity has effect and the effect is the direction, that is the same height will be required on the moon as the earth. For very tall blocks, the forces that acts on the block in the vertical direction is can be obtained from the analysis of the control volume shown in Figure 6.12. The jet impinged on the surface results in out flow stream going to all the directions in the block surface. Yet, the gravity acts on all these "streams" and eventually the liquid flows downwards. In fact because the gravity the jet impinging in downwards sled direction. At the extreme case, all liquid flows downwards. The balance on the stream downwards (for steady state) is

\[ \rho \overline{U_{out}}^2 \cong \rho V_{liquid} g + m g \tag{89} \]

Where \( V_{liquid} \) is the liquid volume in the control volume (attached to the block). The pressure is canceled because the flow is exposed to air. In cases where \( \rho V_{liquid} g > \rho \overline{U_{out}}^2 \) the required height is larger. In the opposite cases the height is smaller.

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