APPH4200 Physics of Fluids: Homework 2

In Chapter 4 of Kundu and Cohen, please do problems 6, 7, 10, and 11. Make any assumptions you find necessary and reasonable to solve the problems, but please state what they are.

Homework 2
Problems from K&C 3rd Edition

6. A rectangular tank is placed on wheels and is given a constant horizontal acceleration a. Show that, at steady state, the angle made by the free surface with the horizontal is given by $\tan\theta = a/g$.

7. A jet of water with a diameter of 8 cm and a speed of 25 m/s impinges normally on a large stationary flat plate. Find the force required to hold the plate stationary. Compare the average pressure on the plate with the stagnation pressure if the plate is 20 times the area of the jet.

10. A hemispherical vessel of radius R has a small rounded orifice of area A at the bottom. Show that the time required to lower the level from h_1 to h_2 is given by

$$t = \frac{2\pi}{A\sqrt{2g}}\left[\frac{2}{3}R\left(h_1^{3/2} - h_2^{3/2}\right) - \frac{1}{5}\left(h_1^{5/2} - h_2^{5/2}\right)\right].$$

11. Consider an incompressible planar Couette flow, which is the flow between two parallel plates separated by a distance b. The upper plate is moving parallel to itself at speed U, and the lower plate is stationary. Let the x-axis lie on the lower plate. All flow fields are independent of x. Show that the pressure distribution is hydrostatic and that the solution of the Navier–Stokes equation is

$$u(y) = \frac{Uy}{b}.$$

Write the expressions for the stress and strain rate tensors, and show that the viscous dissipation per unit volume is $\phi = \mu U^2/b^2$.

Take a rectangular control volume for which the two horizontal surfaces coincide with the walls and the two vertical surfaces are perpendicular to the flow. Evaluate every term of energy equation (4.63) for this control volume, and show that the balance is between the viscous dissipation and the work done in moving the upper surface.