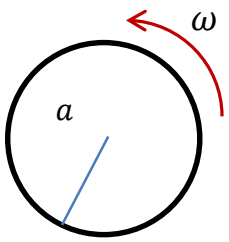
Homework 7

1. Solve the above circumferential momentum equation of circular Couette flow for the velocity $u_\theta(r)$ of the flow in a circular cylinder of radius a.

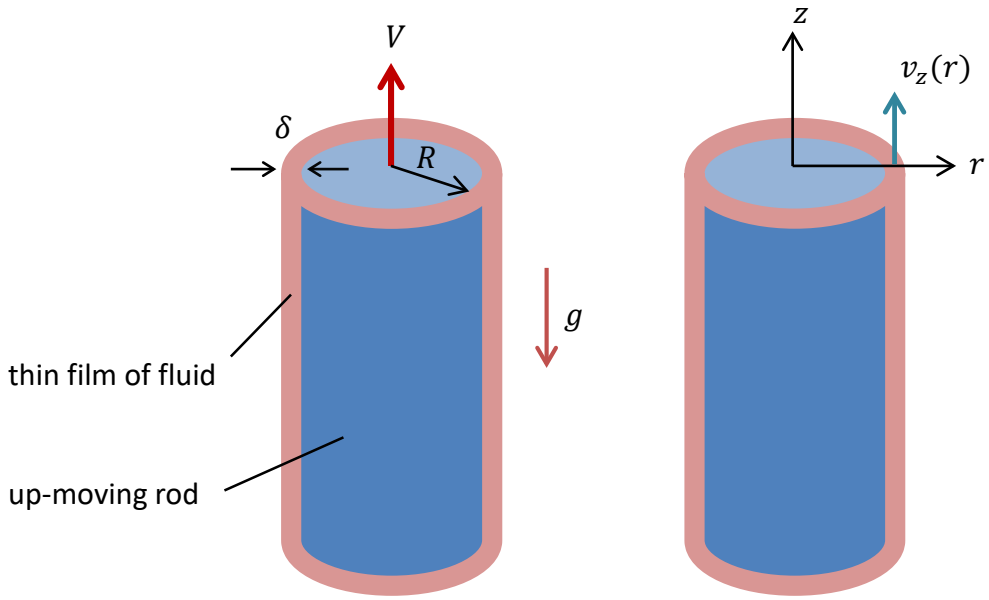


2. A thin film of Newtonian fluid of constant thickness δ (pink color in the figure) is formed on the external surface of a vertical, infinite-long, circular rod (blue color in the figure). The rod moves upward against gravity at a constant velocity V. Assume the fluid flow within the film is steady, the ambient air is stationary, and the friction between the film and the air is negligible. The radius of the rod is R. The gravity g is constant. The kinematic viscosity of the fluid is ν. The coordinates z and r are as shown in the right figure below.

   (a) Express the velocity within the film $v_z(r)$, $R \le r \le R+\delta$, in terms of V, R, g, r, δ, and ν.

   (b) Determine the shear stress τ_{rz} on the surface of the up-moving rod $r = R$.

   (c) If $R \gg \delta$, determine the up-moving velocity of the rod V such that $v_z = 0$ at the outer surface of the film $r = R+\delta$.



3. In Problem 2, if the rod remains stationary, i.e. $V = 0$.

   (a) Express the velocity within the film $v_z(r)$, $R \le r \le R+\delta$, in terms of R, g, r, δ, and ν.

   (b) Determine the shear stress τ_{rz} on the surface of the up-moving rod $r = R$.