

Problem 4D.4

Unsteady annular flows.

- (a) Obtain a solution to the Navier-Stokes equation for the start-up of *axial* annular flow by a sudden impressed pressure gradient. Check your result against the published solution.¹⁰
- (b) Solve the Navier-Stokes equation for the unsteady *tangential* flow in an annulus. The fluid is at rest for $t < 0$. Starting at $t = 0$ the outer cylinder begins rotating with a constant angular velocity to cause laminar flow for $t > 0$. Compare your result with the published solution.¹¹

¹⁰W. Müller, *Zeits. für angew. Math. u. Mech.*, **16**, 227–238 (1936).

¹¹R. B. Bird and C. F. Curtiss, *Chem. Engr. Sci.*, **11**, 108–113 (1959).