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Time-harmonic Stokes Flow of a Newtonian Fluid in the Entrance Region of a Semi-infinite Circular Tube: Insights Involving the Estimation of Entrance Length and the Selection of Appropriate Entrance Boundary Conditions. IRWIN S. GOLDBERG, RICHARD LOMBARDINI, St. Mary's University (San Antonio, Texas) — Semi-analytic solutions to problems involving time-harmonic, axisymmetric Stokes flow in the entrance region of a semi-infinite, rigid, straight circular tube are examined. Double-transform methods are used to calculate sum-over-mode solutions for velocity components, velocity gradients, excess entry pressure, and vorticity. Various types of appropriate entrance conditions are identified in which combinations of pressure, velocity components, and/or velocity gradients are specified at the entrance boundary. The entrance length is estimated from the exponential spatial decay of the lowest normal-mode solution; the estimated entrance length is one-tube-radius for axisymmetric flow and two-tube-radii for non-axisymmetric flow. As a special case, the entrance length is shown to be equal to zero when boundary conditions are specified to have radially uniform pressure with the radial velocity component equal to zero at the entrance. Higher order, non-linear effects are discussed when low (non-zero) Reynolds numbers are involved; these effects include bidirectional streaming and the generation of higher harmonic oscillations. Both steady and time-harmonic flows are considered.

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