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Asymptotic scalings of developing curved pipe flow JESSE AULT, Princeton University, KEVIN CHEN, University of Southern California, HOWARD STONE, Princeton University — Asymptotic velocity and pressure scalings are identified for the developing curved pipe flow problem in the limit of small pipe curvature and high Reynolds numbers. The continuity and Navier-Stokes equations in toroidal coordinates are linearized about Dean's analytical curved pipe flow solution (Dean 1927). Applying appropriate scaling arguments to the perturbation pressure and velocity components and taking the limits of small curvature and large Reynolds number yields a set of governing equations and boundary conditions for the perturbations, independent of any Reynolds number and pipe curvature dependence. Direct numerical simulations are used to confirm these scaling arguments. Fully developed straight pipe flow is simulated entering a curved pipe section for a range of Reynolds numbers and pipe-to-curvature radius ratios. The maximum values of the axial and secondary velocity perturbation components along with the maximum value of the pressure perturbation are plotted along the curved pipe section. The results collapse when the scaling arguments are applied. The numerically solved decay of the velocity perturbation is also used to determine the entrance/development lengths for the curved pipe flows, which are shown to scale linearly with the Reynolds number.

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