Abstract Submitted
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Developing and testing models for flow in microdevices LAURA DICKINSON, University of Bristol, JONATHAN KOBINE, University of Dundee — Microtechnology has developed faster than the corresponding theory describing the physics behind it. The continuum assumptions of classical fluid mechanics break down at the smallest lengthscales; however, Stokes and Poiseuille flow applies for liquid flow in microchannels, and there is merit in using the Navier-Stokes equations as a starting point from which accurate yet parsimonious models of flow in microdevices can be developed. We derive such models for the pressure drop across and the flux through a generic 2D microvalve, which show how each varies with valve opening (the characteristic curve). Eg, the nondimensional pressure drop P in terms of scaled valve opening H can be expressed as

$$P = 1 - 2\frac{(1-H^6)^{\frac{1}{2}} - 1}{H^6}.$$

We verify these models using a finite-element Navier-Stokes solver. Valves with a “long seat” and laminar flows are modeled accurately. We make additions to our models to capture the effects of flow at higher Re. The results of our simulations highlight flow behavior which is interesting to practitioners in the field of applied microfluidics; sharp valve edges produce separation and recirculation, small valve openings produce two jets which recombine in the valve exit. These phenomena give rise to the (turbulent) mixing which is desired but not easily achieved in microdiagnosics.

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