Abstract Submitted
for the DFD16 Meeting of
The American Physical Society

The Bretherton Problem for a Vesicle JOSEPH BARAKAT, Stanford University, ANDREW SPANN, University of Texas at Austin, ERIC SHAQFEH, Stanford University — The motion of a lipid bilayer vesicle through a circular tube is investigated by singular perturbation theory in the limit of vanishing clearance. The vesicle is treated as a sac of fluid enclosed by a thin, elastic sheet that admits a bending stiffness. It is assumed that the vesicle is axisymmetric and swollen to a near-critical volume such that the clearance "e" between the membrane and the tube wall is very small. In this limit, bending resistance is of negligible importance compared to the isotropic tension, allowing the vesicle to be treated as a "no-slip bubble." The effective membrane tension is found to scale inversely with "e" raised to the 3/2 power with a comparatively weak Marangoni gradient. The extra pressure drop is found to have a leading contribution due to the cylindrical midsection, which scales inversely with "e," as well as a correction due to the end caps, which scales inversely with the square root of "e." The apparent viscosity is predicted as a unique function of the geometry. The theory exhibits excellent agreement with a simplified, "quasi-parallel" theory and with direct numerical simulations using the boundary element method. The results of this work are compared to those for bubbles, rigid particles, and red blood cells in confined flows.

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Date submitted: 28 Jul 2016 Electronic form version 1.4