Viscous drops going through membranes with different geometries

Muthu Adithya Ramnarayanan, Ann Ngo, Rocio Navarro
Davis chemical and Biological Research

Introduction

Flow of fluids has dazzled great physicists such as Isaac Newton and Blaise Pascal. This subject was studied after aerodynamics became rampantly important in fields like aerospace. Today, fluid dynamics is used to understand fields such as Ocean currents, Plate tectonics, and evolution of stars. In this study, we are determining if a three-dimensional drop will break, or pass through a microchannel.

Definitions

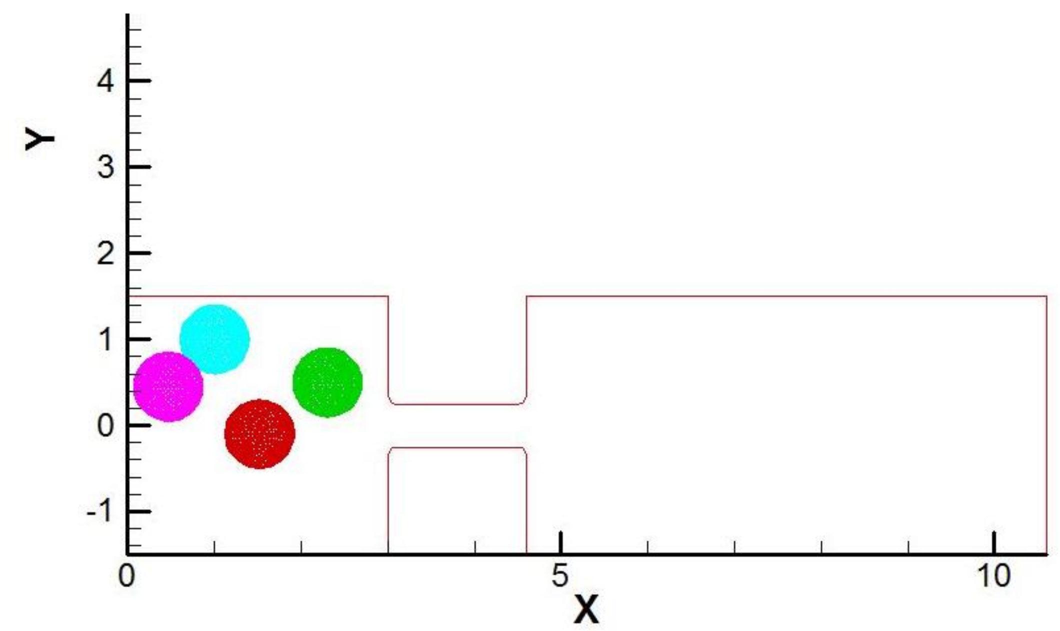
- Surface tension - It is the tendency of a fluid to shrink to have a minimum surface area
- Capillary Number - It is a ratio between viscosity and surface tension of a fluid. It defines how much fluid will deform
- Viscosity - the adhesiveness of fluid due to internal friction
- Reynolds number - The Reynolds number is a dimensionless value that measures the ratio of inertial forces to viscous forces and describes the degree of laminar or turbulent flow.

Theory

This study was done by using models that employ the boundary-integral algorithm. This study was done with low Reynolds numbers, fixed flow rate and varying capillary numbers. This study helps us determine when the drop will break because it couldn't deform due to its viscosity.

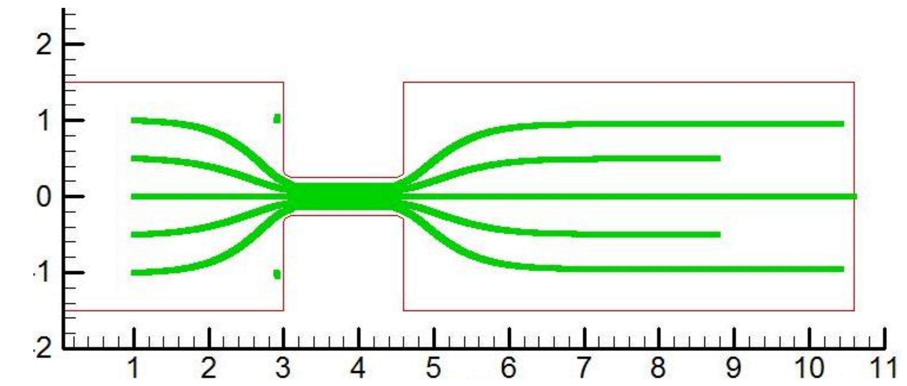
In this study we will be using Droplet Radius as 0.4 and capillary numbers 0.4, 0.8 and 1.2

Initial Positions

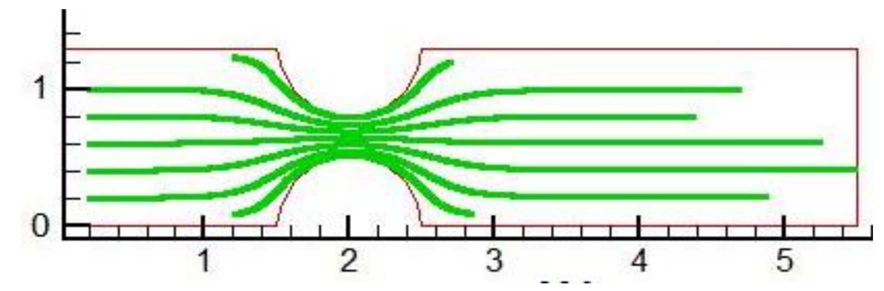


Points	x	y	z
1	2.5	0.5	0.45
2	1	1	0.5
3	1.5	-0.1	0.5
4	0.45	0.45	0.45

Streamlines

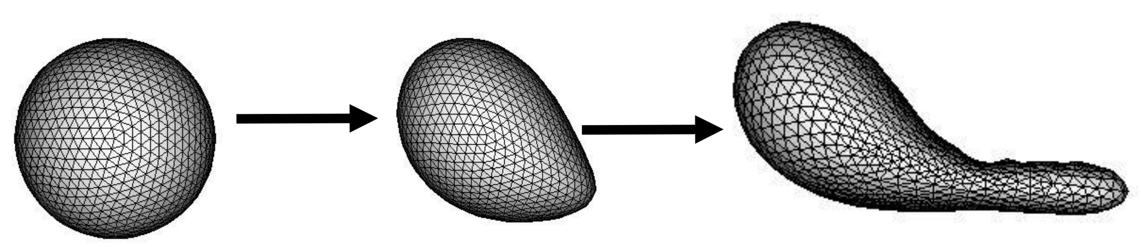


Geometry 1



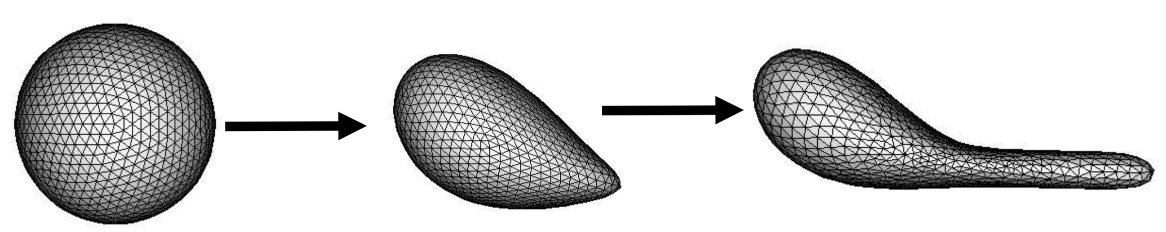
Geometry 2

Breakup



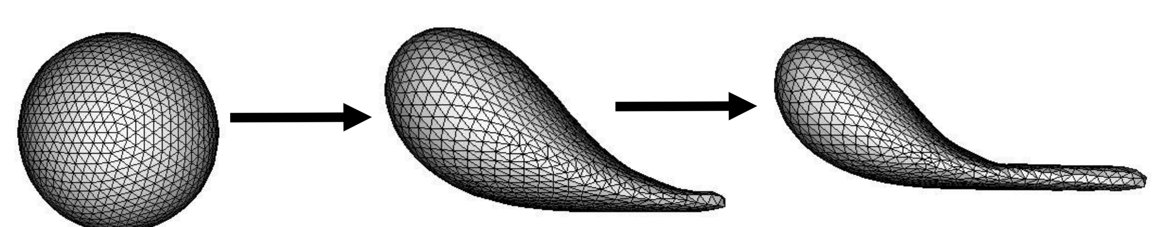
Time = 0 Time = 6 Time = 12

Capillary Number – 0.4



Time = 0 Time = 6 Time = 12

Capillary Number – 0.8



Time = 0 Time = 6 Time = 12

Capillary Number – 1.2

Conclusion

The droplet was observed to have unsteady shapes because with a high capillary number, the viscous forces which cause deformation dominate over the surface tension which resists deformation This study can now be applied in fields such as microfluidic industry and the Petroleum Industry

Experiences

This study was done with a time constraint of 4 weeks which was judiciously used to map out fluids with the same initial positions but different capillary numbers. The modeling was done in a programming language called FORTRAN 90. This was then validated by performing an experiment with a syringe pump and the custom microchannel

Acknowledgements

I Sincerely thank Rocio Navarro for constantly supporting me when in doubt and providing me with ample amount of her resources and time. I thank Ann Ngo for her continuous help in performing the experiment and running simulations. Finally I would like to thank the Davis laboratory for its resources to perform the experiments and run simulations