MAE 6330 – Multiphase Flow Dynamics

Fall 2018

Final coding assignment

Due date: Due Tuesday, December 11th, 2018.

Concepts: A Volume-of-Fluid (VOF) liquid-gas flow solver to simulate a droplet-pool impact.

Teamwork: Please turn in a single document per team of two, with your names on it.

Code: For reference, the following two codes are provided:
(1) a level set/ghost fluid method two-phase flow solver (HW4.zip on Blackboard), and
(2) a VOF-based interface transport code set up for Zalesak's disk test (VOF.zip on Blackboard).

0. I realize this document is coming fairly late, and I apologize for the extended delay! To make up for it somewhat, I am providing a fully-implemented Volume-of-Fluid interface tracking code, so algorithm development should be limited to connecting the VOF to the flow solver.

1. **Testing the VOF code**

   An implementation of an unsplit geometric VOF algorithm is provided in the file VOF.zip on Blackboard (the Journal of Computational Physics paper that describes its implementation is provided as well). Using this code and your previously developed level set code, compare the performance of VOF and level set for the Zalesak disk rotation test case, considering two mesh resolutions: 50^2 and 100^2. Use the following three metrics: (a) a qualitative assessment of the overall accuracy of the shape of the rotated disk, (b) a quantitative assessment of the conservation of the area underneath the interface, and (c) the computational cost.

   Note: to compute the area of the notched circle with VOF, you can simply integrate the VOF function directly. For the level set, you will need to use a smeared-out numerical Heaviside H_ε *as discussed in class to approximate the area underneath the zero isocontour.*

2. **Making a splash with VOF**

   The provided VOF code is not coupled to the flow solver. In class, we discussed two options to do so: either descritizing the Poisson equation using $\rho = \rho_l \alpha + \rho_g (1 - \alpha)$ where α is the VOF field, or using the Ghost Fluid Method (see HW4.zip for a full implementation of it). Choose one of these approaches, and implement it to have a full VOF-based two-phase flow solver. Demonstrate it on the problem of a droplet splashing under gravity on a shallow pool, as illustrated in Fig. 1.

   I recommend using at least a 150^2 mesh, and placing walls all around the domain (although you can certainly use other boundary conditions. You should expect a milk crown to form upon impact, which should develop and dissipate in about 3 to 4 time units.

   Provide a time history of the impact, showing both velocity and VOF field. Comment on the conservation of liquid and gas area, and on the physical realism of the calculation.

   Note: we have discussed the ghost fluid method in the context of level set, not VOF. Here is a naive but acceptable approach for using the ghost fluid method with a VOF field α*: simply assume that* $\alpha - 0.5$ *is like a level set function, i.e., take your distance* φ *in the GFM approach as* $\varphi \approx \alpha - 0.5$*. This places the interface at the 0.5 isosurface of the* α*-field, which is close enough for our purpose.*

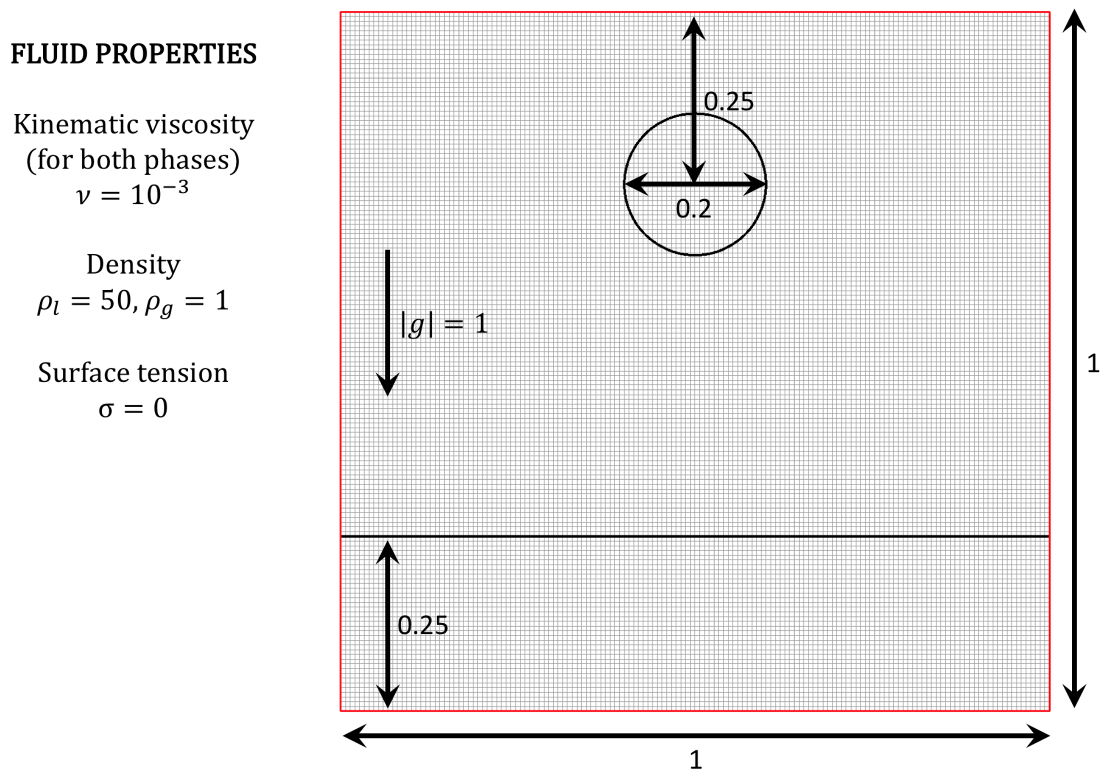

Figure 1: Droplet splashing configuration.