

SECTION 1

Penalty Immersed Boundary Method (PIB)

The Penalty Immersed Boundary Methods is a simple approach try to solve fluid-structure interaction with material bounadary that has mass.

SUBSECTION 1.1

Rigid Body pIB

One kind of problem pIB can simulates is a rigid body in flow. The key of pIB is to consider two sets of Material Points, denoted as $X(q, s, t)$ and $Y(q, s, t)$. Here q, r are Lagrangian Coordinate and t is time. \mathbf{X} is the true boundary points that interact masslessly with the flow, and \mathbf{def} is called the **Ghost Mass**. It doesn't interact with the flow but only with the Material points \mathbf{X} through an imaginary spring.

Explanation 1

- At the start, the Material points' position is updated using fluid velocity interpolated at \mathbf{X} .

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1 X_half_top = X_tube_top + dt / 2 * interpolation(u,
    X_tube_top, Num_b, Nx, Ny, dx, dy);
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- The force acting to the fluid by the Material is modeled by a spring connecting the Ghost point and material point.

$$\mathbf{F}(q, r, t) = K(\mathbf{Y}(q, r, t) - \mathbf{X}(q, r, t)) \quad (1.1)$$

- Then spread the force F to Eucleadian space.
- Numerically solve the time evolution of fluid using Navier Stokes solver.
- Update the Material point position \mathbf{X} .

1.1.1 Implementation : Circle in Flow