Tutorial 2 Microfluidics

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1. **Index Notation**

   Use the index notation and show that the these are equalities:

   A. $$\frac{\partial}{\partial x_i}(p\,\delta_{ij}) = (\nabla p)_j$$

   B. $$\nabla \cdot (\rho \vec{u}) = (\nabla \rho) \cdot \vec{u} + \rho\, \nabla \cdot \vec{u}$$

2. **Flow Simulations**

   A. Write down the boundary conditions (b.c.) for the velocity $\vec{u}$ and pressure for a flow in a 2d-tube driven by a pressure gradient. You need one b.c. for each boundary, i.e. the walls and the inlet/outlet, and component of the velocity. The pressure at the walls are determined by the incompressibility condition. For help look into the code.

   B. Do the same for a flow in a 2-tube driven by the upper wall. Again, check you answer with the boundary conditions stated in the code.

   C. Conduct simulations for pressure driven and wall driven flows. Try to obtain a parabolic profile for the pressure driven flow and a linear profile for the wall driven flow. Discuss the results. What is the effect of the time step of integration, and the CFL-number. Look up the meaning of the CFL number.

3. **Navier Stokes Equation**

   The electrostatic force is a body force $\vec{F} = q\,\vec{E}$, where q is the charge and $\vec{E}$ is the electric field. Add this force in the derivation of the Navier Stokes Equation and write a Navier Stokes Eq. with electrostatic body forces using a charge density ρ_{el} and the electric field $\vec{E}$.