Lab-on-a-Chip 2010 (Spring semester).
Computational COMSOL assignment

Problem 1.

Mixing is a serious problem in Lab-on-Chip design due to generally laminar character of microflow. Several active and passive mixer designs were suggested to overcome the problem. However, recently it was shown [Lauga et al., Physics of Fluids 16, 3051, 2004) that even at very small Reynolds number, vertical (z) component of the velocity (e.g. perpendicular to the channel top and bottom) is zero in the channels of constant cross-section and curvature only. Changing cross-section or curvature of the side walls leads to non-zero z component of the velocity.
Check the theory and calculate **z** and **y** component of the flow velocity in a channel of varying cross section shown below at flow rates of 50, 100 and 200 µl/min.
Be careful with the grid. Too coarse grid would create too much noise, too fine one will make calculation run out of memory. UMFPAC seems to be more efficient for this problem.

Please include in your report:

- a 3D slice plots of your x, y z components of the velocity profile (at a quarter-height and 10 sections along x. Where do you expect maximum of V_z?
- a 2D YZ cross-sections at x=0.3 and x=0.55 and XY at z=1.25e-5 for every flow rate used
- plot showing the dependence of rms Vz on the velocity (e.g. <Vz>rms averaged over the whole domain)
- a short explanation on how would you use this device

Modeling parameters:

⇒ Channel height: 50 µm
⇒ Flow: 50 ul/min, 100 ul/min, 200 ul/min, 400ul/min
⇒ Channel dimensions: as shown in Fig 1
. 2^{nd} order Bezier is used for curved parts
⇒ Assume the liquid properties are the same as water.

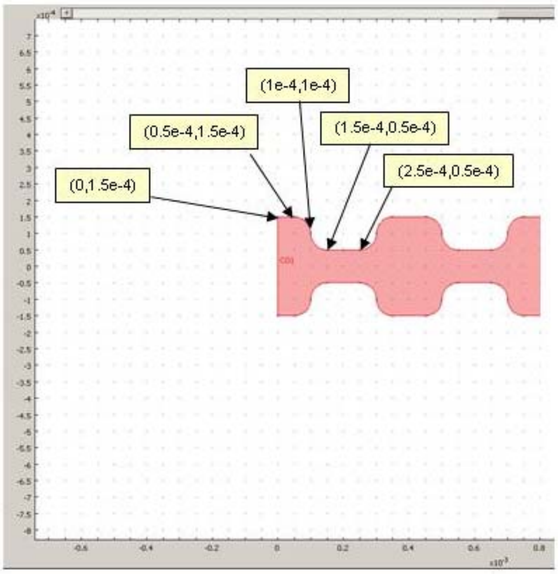

Fig 1. Geometry of the channel.

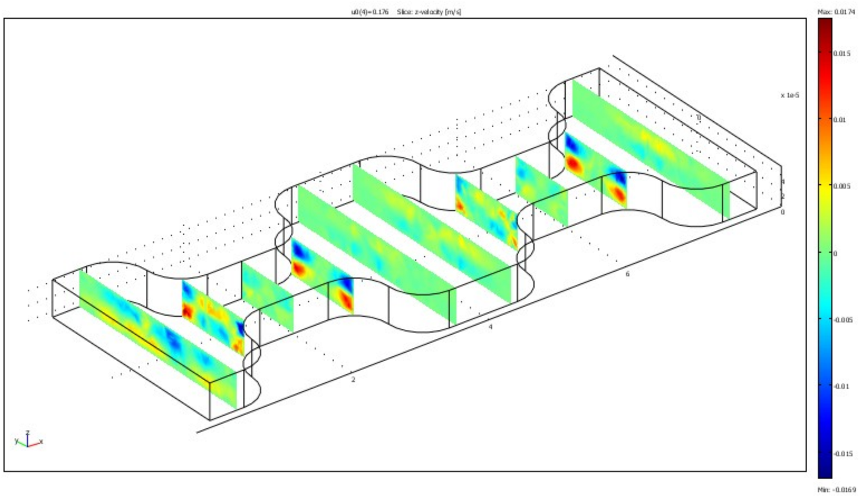

Fig. 2 z-component of the flow velocity in a channel of variable cross-section