MT-0.6081 Microfluidics and BioMEMS, Exercise 2 Microfluidics

This is a home exercise. Answer to the questions at home and return before the next weeks exercise session. 8 points total. Return to Mycourses before 12:00 on 27.1.2016. The exercise session will be 14:15 on 27.1.2016.

If you are participating from a university other than Aalto and cannot access Mycourses, then you can instead return by e-mail to ville.p.jokinen@aalto.fi. Same deadline.

1. Laminar flow (1 pt.)

a) A microchannel with a square cross section (200µm x 200µm) has a volumetric flow (water) rate of 10 µl/min. Estimate whether the flow is laminar or turbulent by calculating the Reynolds number.

b) You are swimming in water. Estimate whether the flow around you is turbulent of laminar by calculating the Reynolds number.

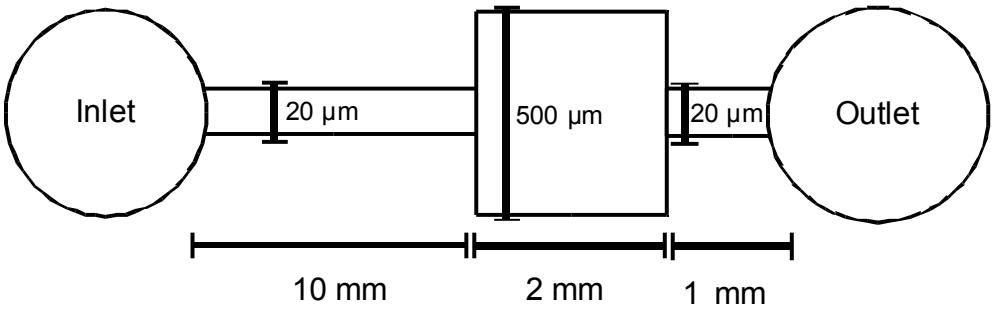
2. Microfluidic circuit (3pts.)

A microfluidic chip consists of an inlet, an outlet, two 20 microns wide channel segments and a 500 microns wide reaction chamber as shown in the picture (top view). The channel depth throughout the chip is 80 µm and the lengths and widths of the three segments have been marked to the picture. The liquid used on the chip is water at 20°C (µ= 1 mPa*s).

a) Calculate the fluidic resistance of the chip using two methods. First, calculate using the hydraulic radius approximation. Second, calculate the flow resistance according to:

$$R_H \approx \frac{12\mu L}{wh^3(1-0.630h/w)}$$

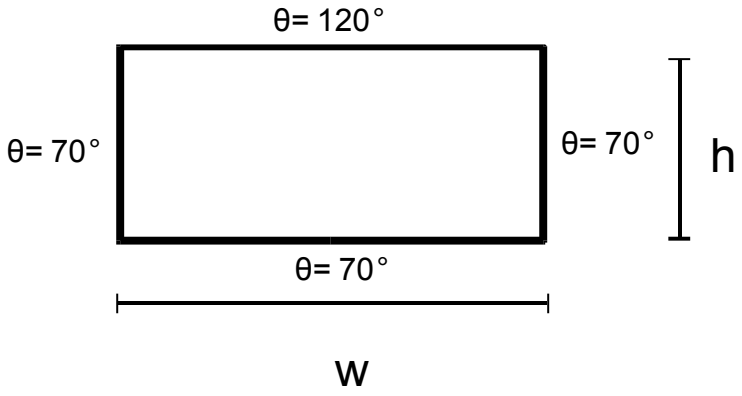
b) Calculate the volumetric flow rate (in **µl/min**) when a 1000 Pa pressure difference is applied between the inlet and the outlet. Use the flow resistance calculated according to the formula in a), and not the hydraulic radius approximation.



3. Capillary filing (3 pts.)

a) A microfluidic channel has a rectangular cross section of 20 µm x 20 µm and the water contact angle is 20°. What is the bond number (when the channel is in a horizontal orientation)? What is the capillary pressure? If the channel was of infinite length and was turned vertically, how high would the liquid rise against gravity?

b) A microfluidic channel has a cross section and contact angles as depicted below. What is the maximum width/height ratio that still leads to spontaneous capillary filling?



4. Surface energy, adhesion, cohesion, contact angle (1 pt.)

A liquid droplet sits on top of a solid surface, surrounded by air ambient. The work of adhesion between the liquid and the solid is exactly half of the work of cohesion of the liquid. What is the contact angle?