CHEM-E8135 Microfluidics and BioMEMS
Exam in MyCourses, 15.4.2024, 14:00-17:00

Return the exam to the return box before 17:00 (or 18:00 if you have been granted extra time).
Return a single pdf or docx file.

If MyCourses crashes or otherwise as last resort, return by email ville.p.jokinen@aalto.fi

Exam has 4 questions, **answer three questions out of four.** If you answer all four questions we will have to grade all four and drop your best points ☹.

Each question is graded as max 6 points, but exam points are scaled up by a factor of 30/18 so that the exam is worth a total of 30 points on the course.

1. Laminar flow fundamentals 6p

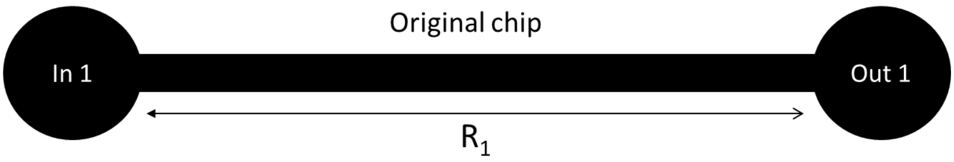
You have a simple channel (**same cross sectional dimensions throughout**) flowing from inlet 1 to outlet 1 with a total hydraulic resistance of R_1. You want to make a new design with an added extra channel that starts from the exact midpoint of the channel that goes to outlet 2. You want **99%** of the flow from inlet 1 to go to outlet 1 and just **1%** to go to outlet 2.

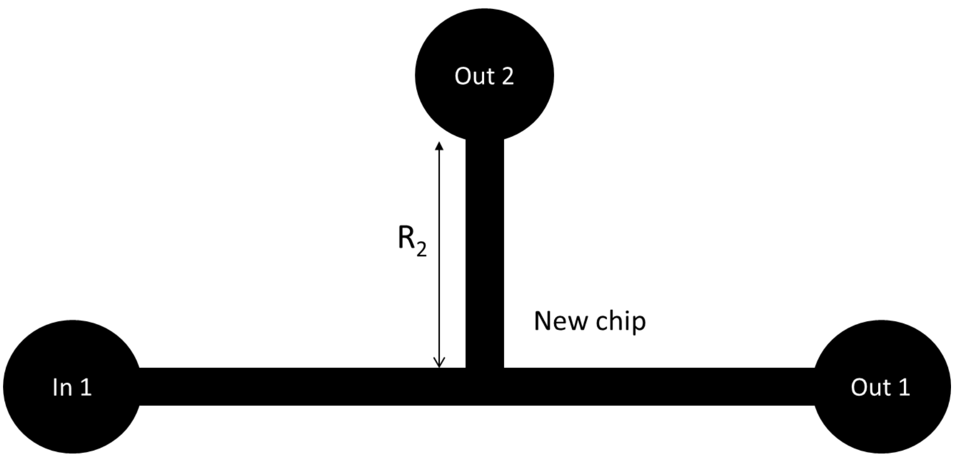
a) Lets call the hydraulic resistance of the newly added channel R_2. Qualitatively, explain whether R_2 should be bigger or smaller than R_1 and why. **1p**

b) Quantitatively, what should be the hydraulic resistance R_2 as a function of R_1? **3p**

c) Let's say that the original channel had a rectangular cross section of 100 µm x 100 µm and a length of 1 cm. Propose dimensions for the new channel to fulfill the criteria calculated in b). The lengt of the added channel needs to be between 0.1 cm and 10 cm and the cross section needs to be between 1 µm and 1 mm. **2p**

(a design like this could be used for example to get a small aliquot of reaction products for quality control. Majority of the product goes to outlet 1 whereas an aliquot is directed to outlet 2.)





2. Microchip CE with optical detection, chip design 6p

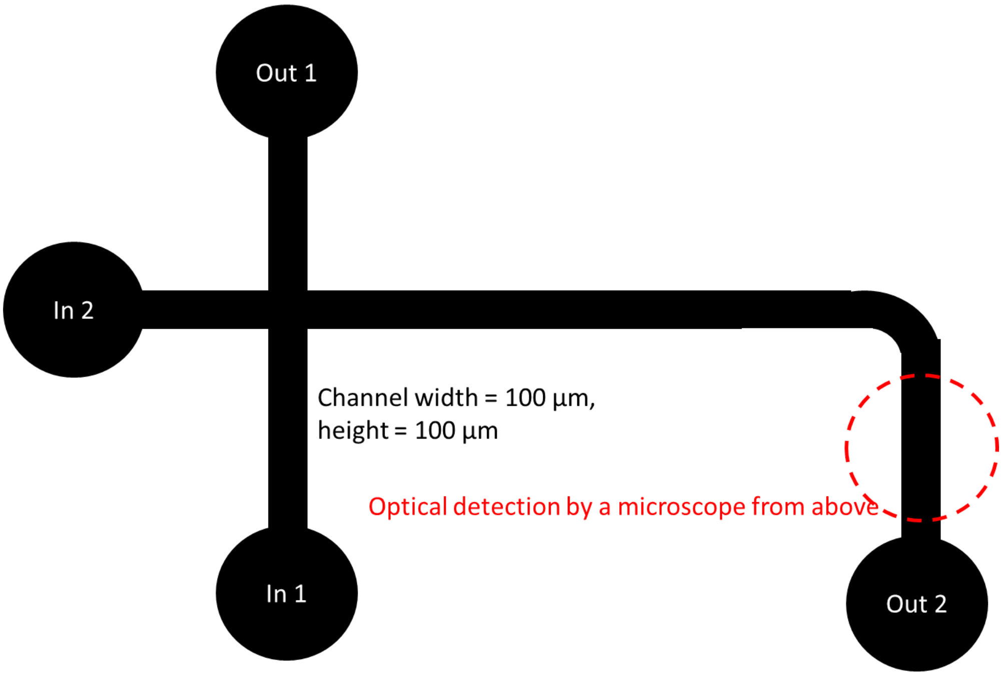
You have fabricated the capillary electrophoresis chip shown in the image below. The chip consists of a cross injection (sample injected from Inlet 1 to Outlet 1) and the main separation channel (from Inlet 2 to Outlet 2). The chip is made from PDMS (3 walls) bonded on glass (1 wall). The chip is operated by electroosmotic pressure and uses optical detection from above the chip.

In your first test run you get a disappointing performance: the separation efficiency is low and the detector struggles to detect the poorly separated peaks.

Improve the design! You need to stick to CE separation and optical detection, but you are free to change geometry, materials etc.

a) What could you change in your next version of the chip to improve the poor separation efficiency? **4p**

b) What could you change in your next version of the chip to improve the insufficient optical detection? **2p**



3. Microfluidics for point-of-care diagnostics at home

I asked ChatGPT 3.5 the following question: **“**What is the main advantage and disadvantage of microfluidics for point-of-care diagnostics at home?”.

Analyze the answer provided.

a) Pick and briefly explain one advantage and one disadvantage of the answer that you most strongly agree with. **3p**

b) Pick and briefly explain one advantage and one disadvantage of the answer that you most strongly disagree with. This could be either because it is wrong or alternatively it is not a main advantage/disadvantage but a lesser factor. **3p**

“The main advantage of microfluidics for point-of-care diagnostics at home is its potential for providing rapid and convenient testing solutions with minimal sample volume requirements. This enables individuals to monitor their health status conveniently at home, facilitating early detection of diseases and timely intervention.

However, a significant disadvantage of microfluidics for home diagnostics is the complexity involved in device fabrication and operation. Microfluidic devices often require specialized fabrication techniques and instrumentation, which may pose challenges for widespread adoption and affordability, particularly in resource-limited settings. Additionally, user training and education may be necessary to ensure proper operation and interpretation of test results, which could impact user acceptance and usability of microfluidic-based devices.”

4. Materials 6p

Microfluidic chips are made from a wide variety of polymers, silicon, glass and other materials. The plethora of materials used is a consequence of microfluidics being a very cross disciplinary field in terms of fabrication techniques and application areas.

Imagine that you are a materials scientist and you are planning to invent a new material that will surely become the most widely used material in microfluidics and thus help save lives and make you a millionaire.

As the first step of your design process, **write a wish list of properties you would like your material to have. Briefly expain why this property is beneficial for a material used in microfluidics.**

Think broadly from fundamental science to applications and use in society.

(note: you are not expected to name any specific real material that fulfills all of your wishes, it likely it does not exist and compromises would need to be made)