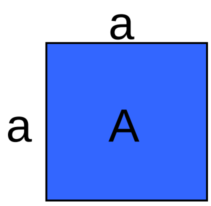
BMT-3076 Microfluidics

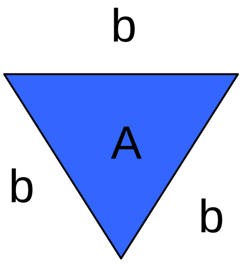
E2: FEM modeling pressure driven flows

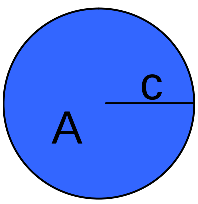
Study pressure driven flow in straight microchannels with typical microfluidic cross-sections presented below. Calculate analytically (like in E1: Calculation exercise I) flow rate and hydraulic resistance for each of the channel types. Use Comsol Multiphysics to solve the problems also numerically and calculate also velocity at the outlet center of the channel. Use three-dimensional modeling space. Estimate the error between the analytical and the numerical solution.

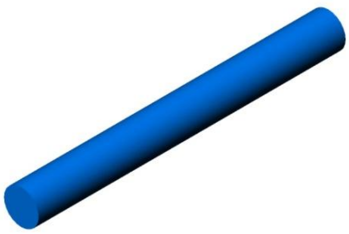
Cross-sectional area A is equal for all the presented microchannels.

a = 100 µm
l = 1 mm
η = 0.001 Pa s
ρ = 1000 kg / m^3
Δp = 1 kPa







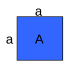
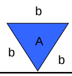
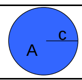


Hints:

- 3d, Fluid flow / Single phase flow / Laminar flow (spf), stationary
- Triangle geometry: Work plane, draw geometry (**remember h = sqrt(sqrt(3))*a**), Extrude, distance = 1 mm,
- Add point to the center of the outlet. In the case of triangle the center is the same as the center of the biggest circle drawn inside the triangle (r = 0.5*(h-b^2/(4*h)))
- Fluid properties: η, ρ (note η is μ in Comsol)
- End 1 of the channel: Outlet, Zero Pressure
- End 2 of the channel: Boundary Stress (do not use inlet), Normal stress, normal flow, Δp
- Mesh:
  Circle: Size / predefined: Coarse, Calibrate for fluid dynamics
  Square and triangle:
    - Size / predefined: Extra coarse, Calibrate for fluid dynamics
    - Boundary layers / Boundary layer parameters
      - Number of boundary layers 5
      - Boundary layer stretching factor 1.5

- Velocity: Derived values / Point evaluation
- Flow rate: Derive values / Surface integration (select outlet)

The results (fill the table below) should be returned to the assistant using Moodle before the next exercise.

			
Velocity v	Numerical *Analytical* *0.7367*	Numerical *Analytical* *0.6415*	Numerical *Analytical* *0.7958*
Flow rate Q	Numerical *Analytical*	Numerical *Analytical*	Numerical *Analytical*
Hydraulic Resistance R_{hyd}	Numerical *Analytical*	Numerical *Analytical*	Numerical *Analytical*