UNIVERSITY OF BIRMINGHAM

Computational Modelling and Simulation of the Human Duodenum

COMSOL CONFERENCE EUROPE 2012

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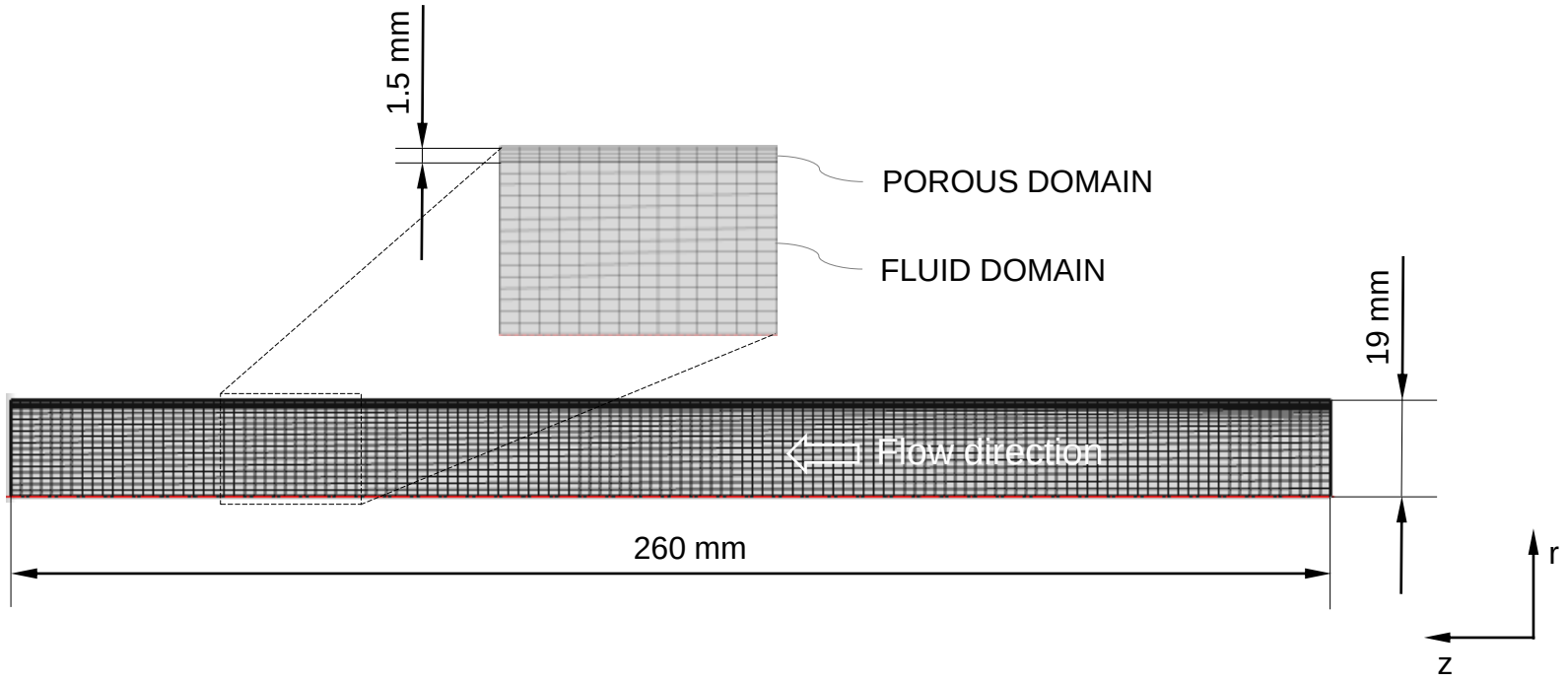
Human Duodenum Model

The human duodenum model is approximately 260 mm long and 35 mm wide elastic tube with porous wall of thickness 1.5 mm that can mimic peristaltic movements.

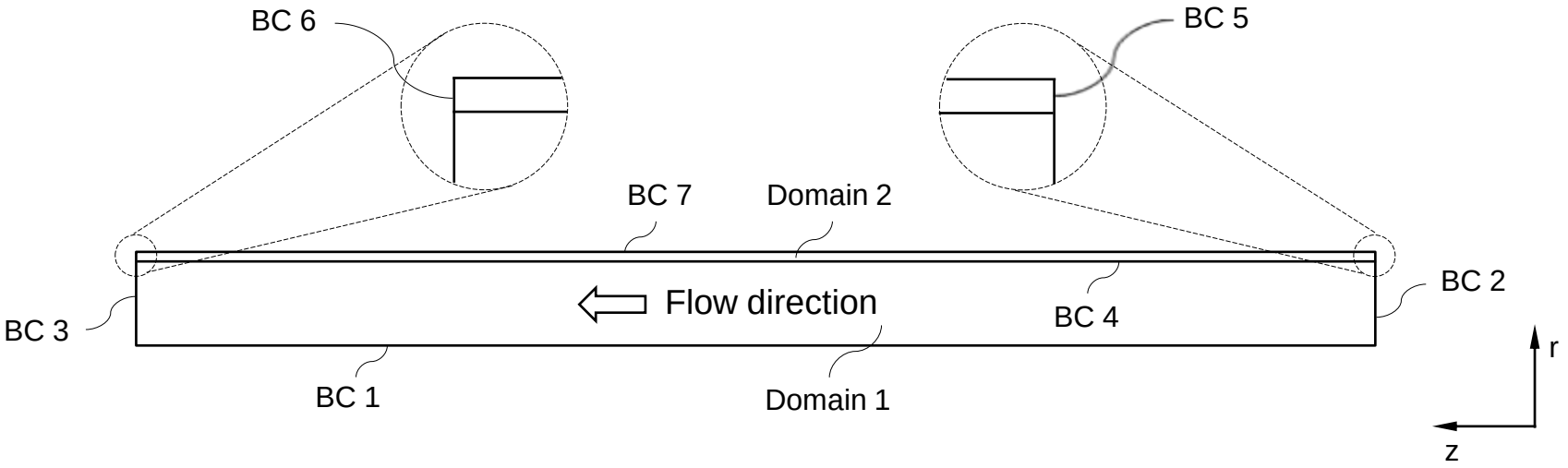
The model assumes:

Neglected pancreatic ducts and segmentation movements
First order hydrolysis reaction of starch producing glucose
Material of the duodenum-like elastic and porous tube is silicone
Fluid flow is Newtonian fluid
Density of the fluid flow is 970 kg/m^3
Viscosity of the fluid flow is 0.1 $Pa \cdot s$
Young's modulus of the tube is $1.0 \cdot 10^7$ Pa
Poisson's ratio of the tube is 0.48
Density of the tube is 1140 kg/m^3
Load (force) is $1.5 \cdot 10^5$ N/mm^2

Geometry and Computational Mesh



Boundary Conditions

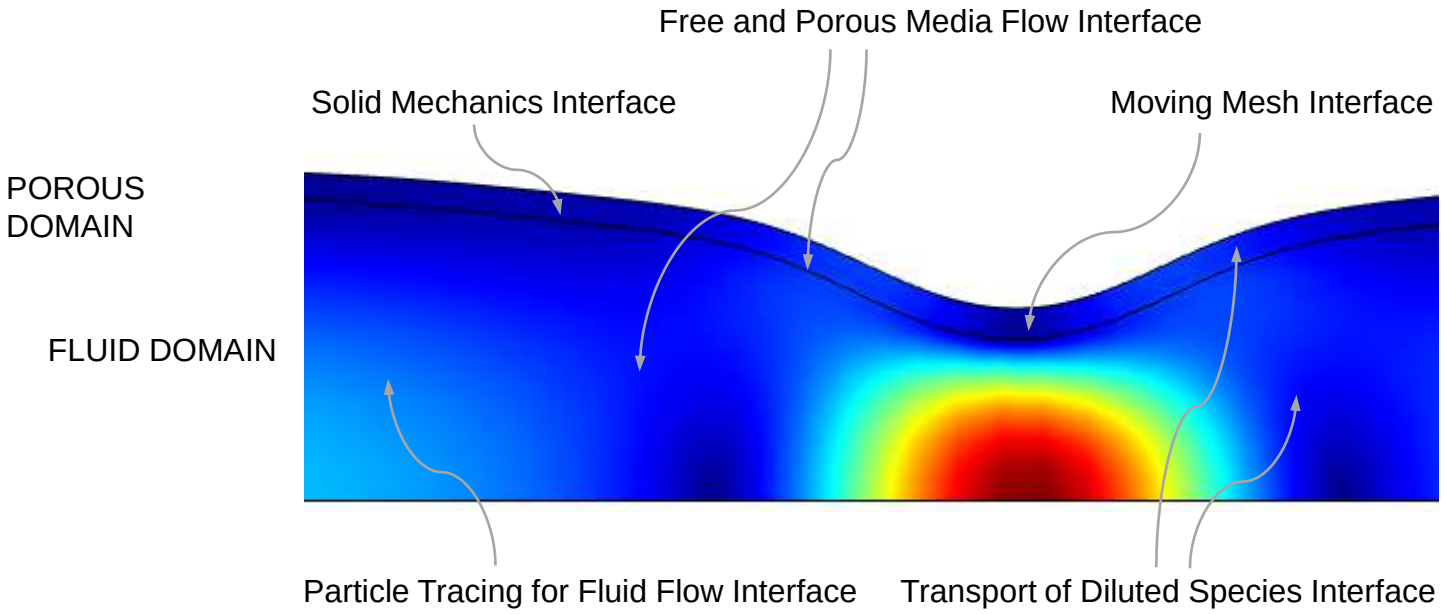


Modelling and Simulation Strategy

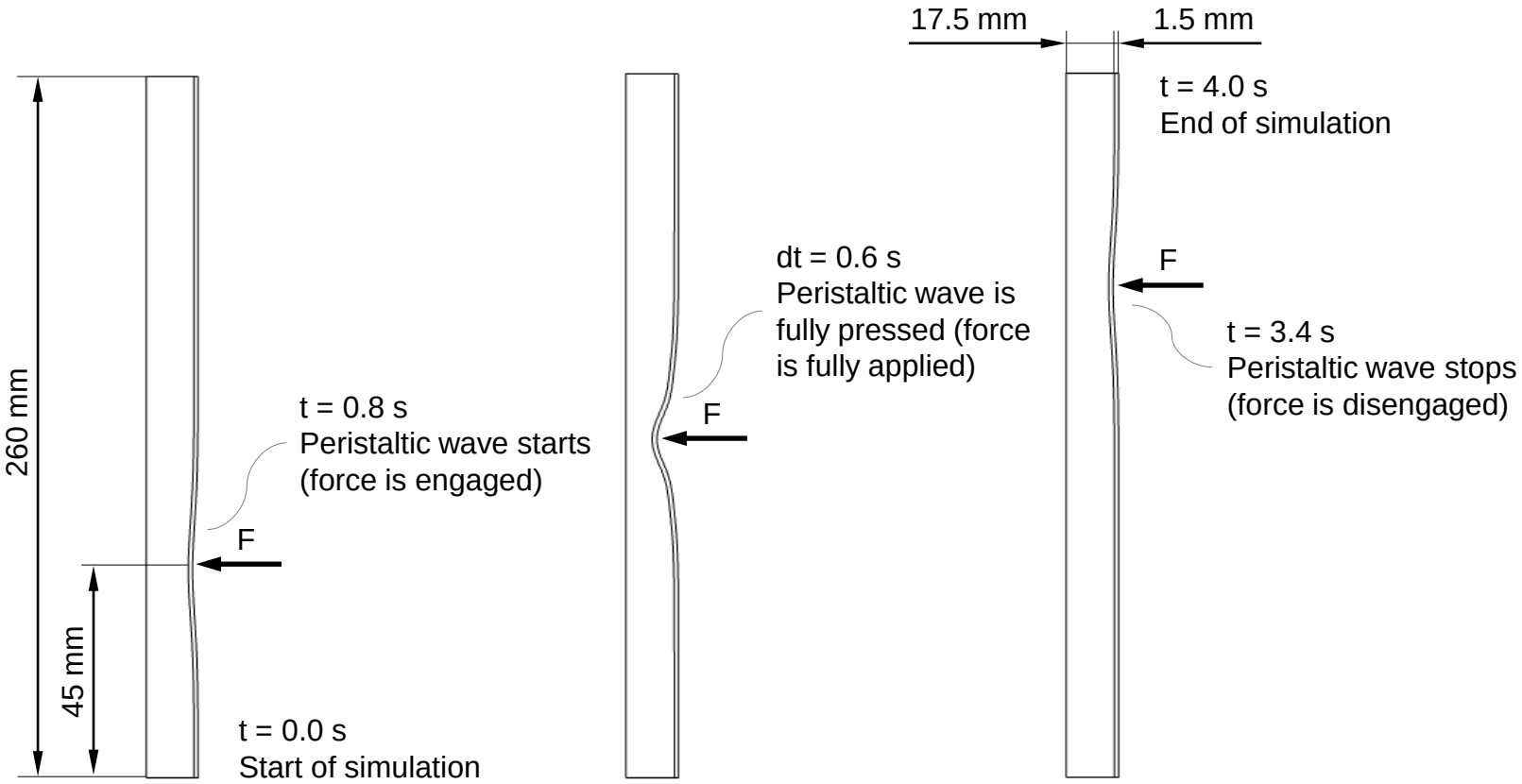
The human duodenum model is modeled with COMSOL Multiphysics 4.2a. It consists of five different interfaces:

1. Free and Porous Media Flow Interface
   Simulates laminar flow inside the human duodenum-like elastic and porous tube and through the porous wall of the same tube
2. Solid Mechanics Interface
   Simulates peristaltic movements of the human duodenum-like tube
3. Moving Mesh Interface
   Couples Free and Porous Media interface and Solid Mechanics interface into an integrated fluid-structure interaction part
4. Particle Tracing for Fluid Flow Interface
   Visualises mixing of flow particles inside the human duodenum-like tube
5. Transport of Diluted Species Interface
   Simulates the first order hydrolysis reaction of starch producing glucose inside the human duodenum-like tube and diffusive flux of glucose through the porous wall of the same tube

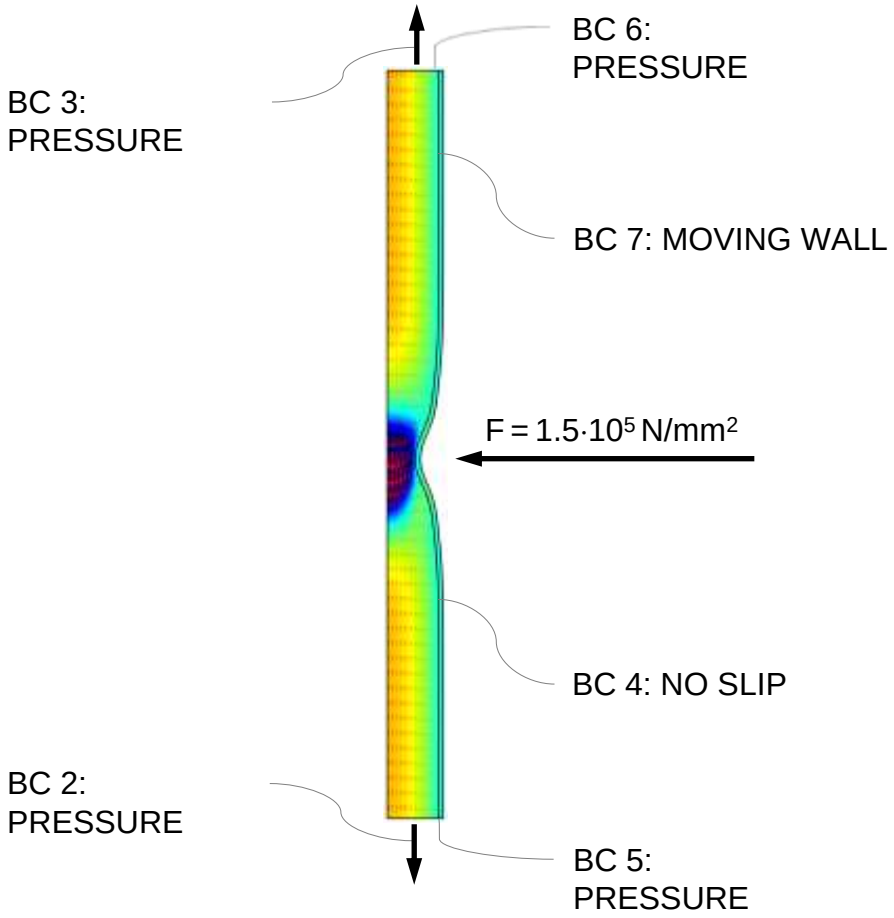
Modelling and Simulation Strategy



Peristaltic Movements

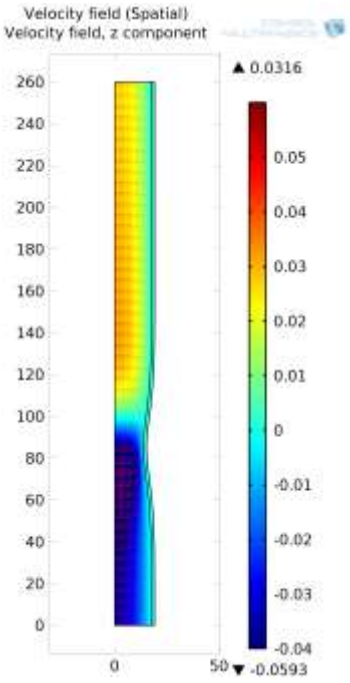


Fluid Flow Boundary Conditions



Fluid Flow Modelling Results

Velocity field in the axial direction [m/s] represented as surface plots and spatial direction of velocity fields represented as vector plots



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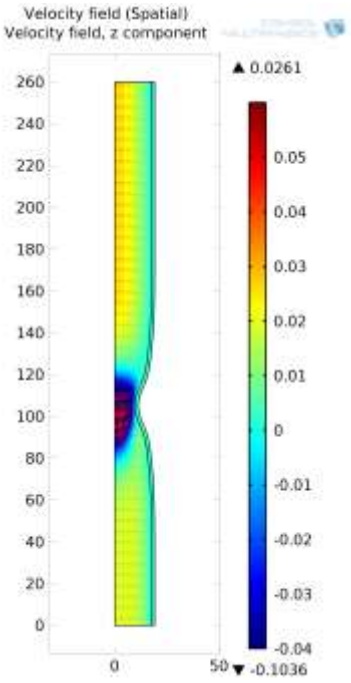

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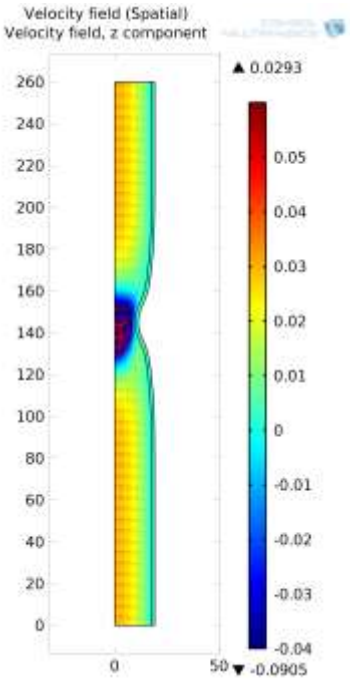

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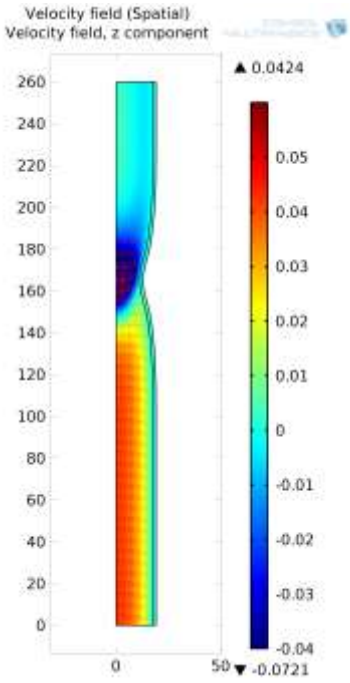

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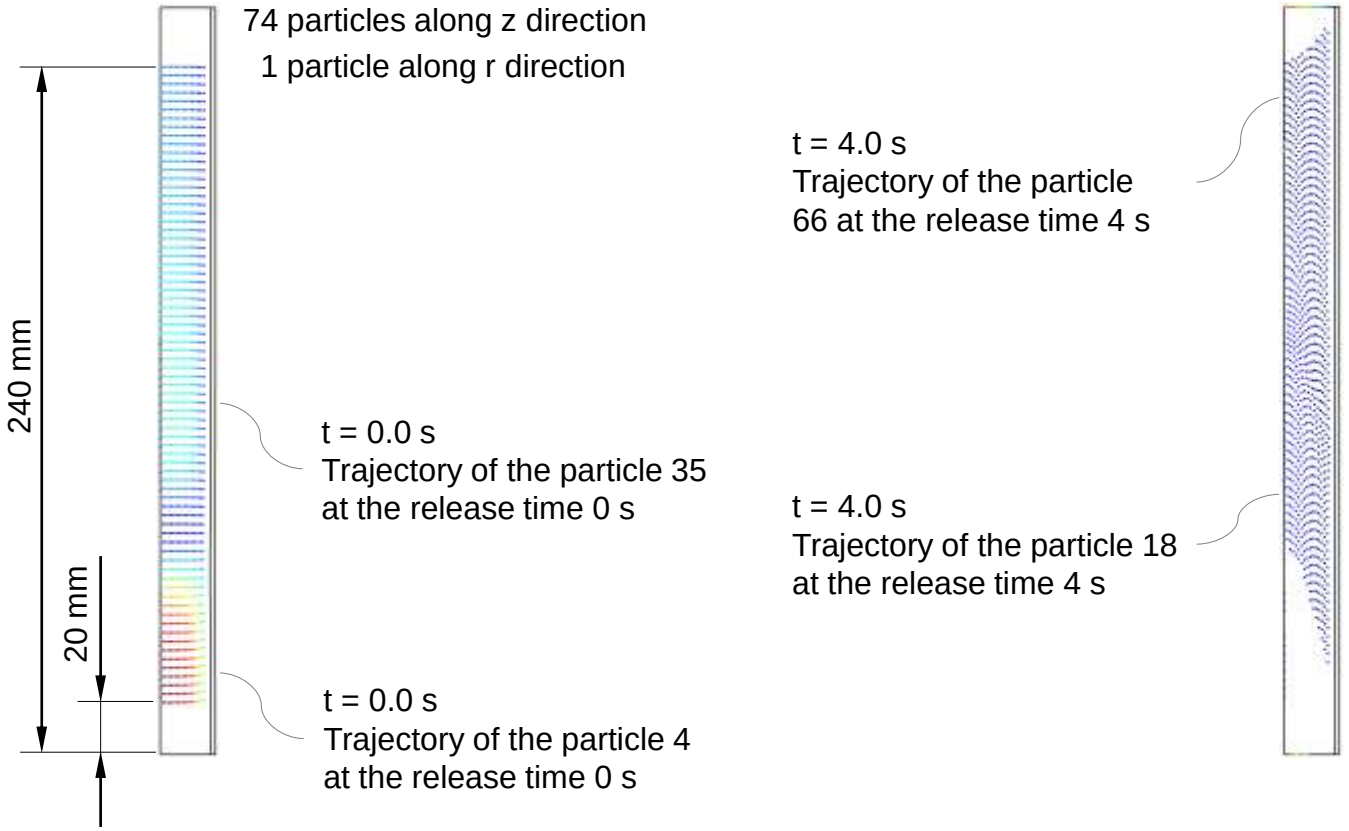
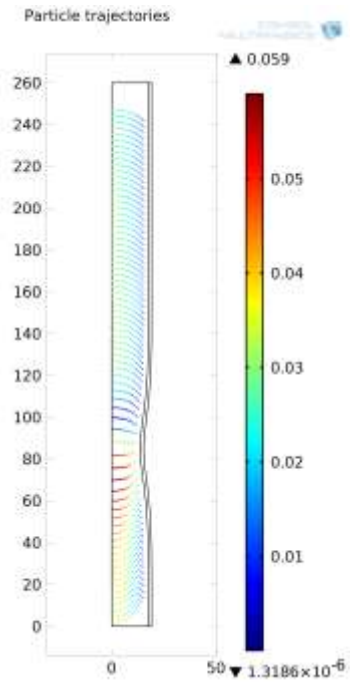
Particle Tracing Boundary Conditions



Particle Tracing Modelling Results

Particle trajectories of the fluid flow represented as surface plots



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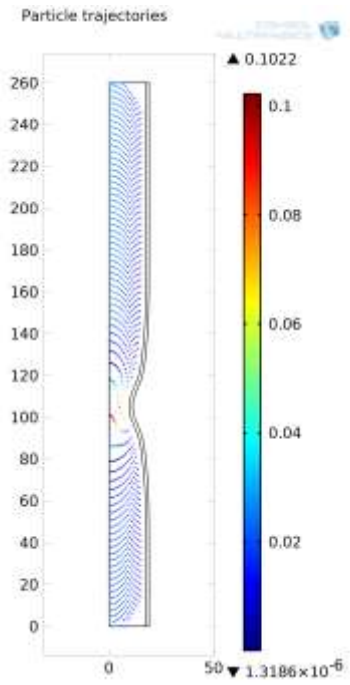

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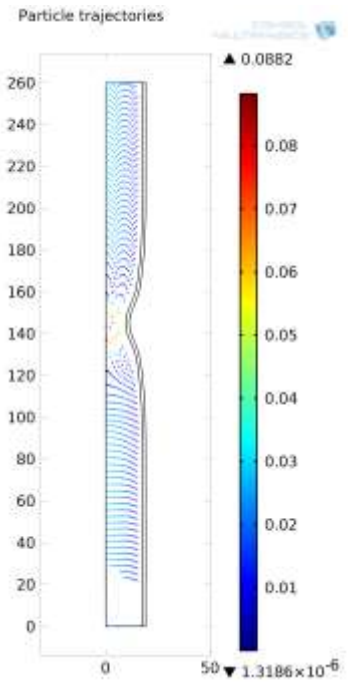

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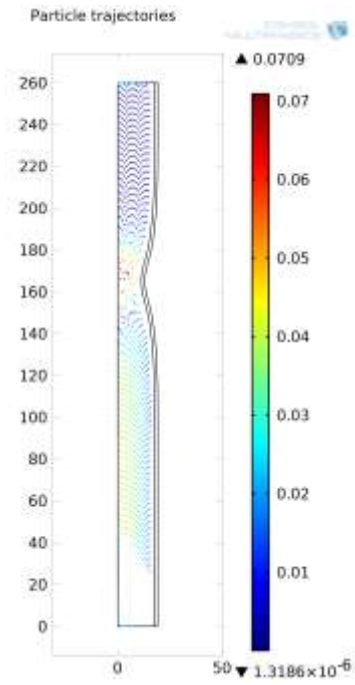

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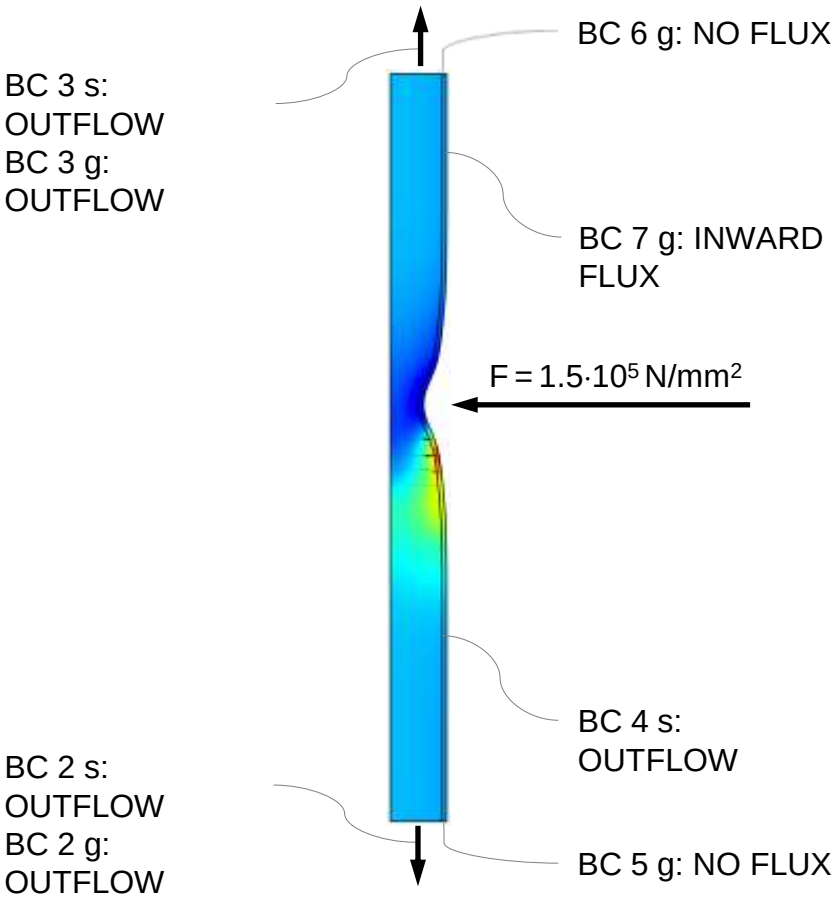
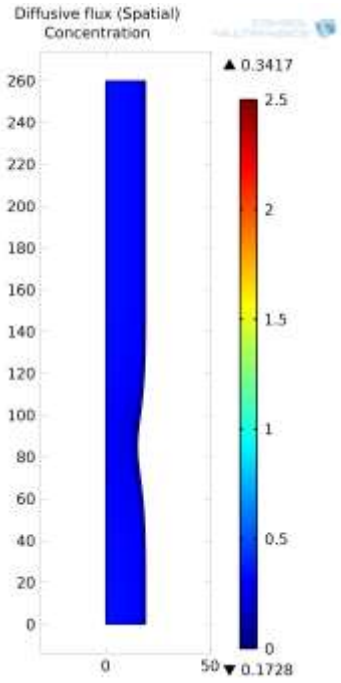
Concentration Boundary Conditions



Concentration Modelling Results

Concentration field of glucose [mol/m^3] represented as surface plots and spatial inward diffusive flux of glucose through the porous silicone wall represented as vector plots



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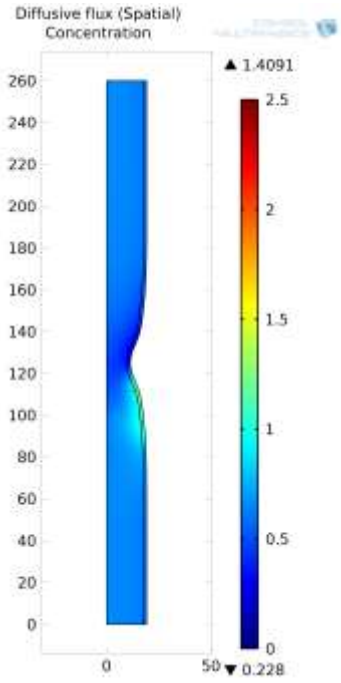

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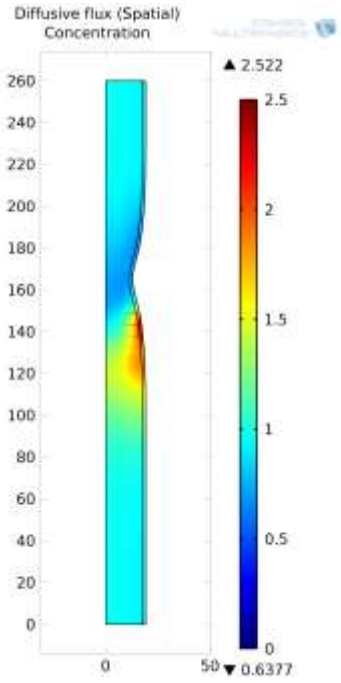

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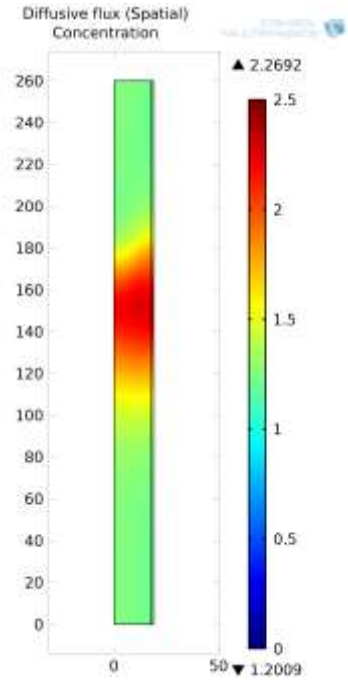

4.0 s

Acknowledgments

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