MF2E department
3HY/Master FEIP
INP Toulouse – ENSEEIHT

Transfers in Porous Media
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Syllabus

Prerequisites To take this lecture, it is compulsory to know some basics in physics, hydrostatics and hydrodynamics. Following notions must be understood :

- hydrodynamics at low Reynolds number (especially Poiseuille law)
- way to do local and integral balances
- isotropic diffusion of particles in a fluid (Brownian motion)
- thermal diffusion in homogeneous media

The aim of this lecture is to present some aspects of transport in porous media from pore scale to porous media scale. At pore scale, specific small-scale hydrostatics will be presented then electrokinetics effects due to wall surface charge will be described. Then an overview of porous media description and properties will be proposed, followed with the upscaling methods to translate local transport equations to global ones. The first application will be the hydrodynamic transport through a porous media with the Darcy's law derivation. Then some lectures will focus on dispersion and diffusion in porous media, both about particles/molecular transport and heat transfer. This lecture will be decomposed in **five parts** with specific objectives spread on eleven 1h45 lectures.

1 Hydrostatics and transport at individual pore scale

Objectives At the end of these lectures, you should be able to :

- explain the surface effects on small-scale hydrostatics
- demonstrate the main relations related to surface tension (Young, Jurin, Laplace)
- summarize the main coupled transfers through an individual pore (electro-osmosis, diffusio-osmosis, ...)
- adapt previous notions to solve an unknown coupled transport phenomenon

2 Upscaling to porous media

Objectives At the end of these lectures, you should be able to :

— describe some natural and artificial porous media
— define the Knudsen number
— define and explain the main properties of a porous media (porosity, tortuosity, saturation)

— explain the Representative Element Volume
— summarize the different upscaling methods for porous media
— compute the spatial average of a scalar field in a porous media

3 Hydrodynamic transport in a porous media

Objectives At the end of these lectures, you should be able to :

— summarize and interpret the Darcy's law
— compute an estimation of the permeability of a porous media
— cite some experimental methods to measure permeability

— define the Klinkenberg effect
— apply the Darcy's law without neglecting inertia (Ergun's law)
— choose the good approach to assess the hydrodynamic transport in a porous media

4 Diffusion and dispersion in a porous media

Objectives At the end of these lectures, you should be able to :

— name the different kind of dispersion mechanisms in a porous media
— write and apply the Fick's law
— demonstrate the Taylor's dispersion in a cylinder

— describe diffusion phenomenon in porous media
— write and interpret the advection-dispersion equation
— cite and describe some applications of dispersion in porous media

5 Thermal transfer in a porous media

Objectives At the end of these lectures, you should be able to :

— cite and describe the three thermal transfer mechanisms in porous media
— summarize the conduction thermal transfer model
— interpret different models of equivalent conductivity

— differentiate natural and forced convection
— summarize the convection thermal transfer model
— define the Rayleigh and Nusselt numbers in porous media

Examination will mix the analysis of a recent scientific article and classic exercises related to objectives detailed above.