PhD program in Civil, Chemical and Environmental Engineering

Curriculum in Fluid Dynamics and Environmental Engineering

Academic year 2021/2022

1. Title of the course

UPSCALING TECHNIQUES IN CONTINUUM MECHANICS

2. Contents

1. Generalities about homogenization and volume averaging (week 1)
   a) Fundamental definitions and mathematical tools.
   b) Differences and similarities between the two approaches.
   c) Recent extensions of the theory
2. Solid and fluid mechanics in porous media (weeks 1-3)
   a) Upscaling the elasticity model in a deformable medium without influence of the saturating fluid.
   b) Steady, incompressible and Newtonian flow in rigid and homogeneous porous media.
   c) Unsteady, incompressible and Newtonian flow in rigid and homogeneous porous media.
   d) Steady, incompressible and non-Newtonian flow in rigid and homogeneous porous media.
   e) Steady, incompressible and Newtonian flow in rigid and heterogeneous porous media.
   f) Steady, incompressible and Newtonian flow in deformable and homogeneous porous media.
3. Heat and mass transfer in porous media (week 4).
   a) Diffusion, convection and reaction in homogeneous porous media.
   b) Heat transfer involving interfacial transport resistances: The one and two-equation models.

At the end of the course the student will be able to:
1. Understand the fundamentals of the homogenization and volume averaging methods.
2. Identify the similarities and differences between the two approaches.
3. Derive effective medium models, both in the bulk and near porous media boundaries, for momentum,heat and mass transport.
4. Numerically solve closure problems using Comsol Multiphysics.

3. Structure of the course

Every class in the course involves three stages:

1) The students should read material provided beforehand
2) During the class, algebraic and technical details will be cleared out and in-depth discussions will be promoted
3) After class the students have to demonstrate that they have acquired the knowledge from each week of the course.

In addition, the students should apply the material learned in the course in a group project of their interest. The classroom sessions will involve some simulation workshops where the ancillary closure problems will be numerically solved using Comsol Multiphysics.

4. Lecturers

Francisco J. Valdés-Parada (Universidad Autónoma Metropolitana-Iztapalapa, Mexico City, Mexico) and Didier Lasseux (I2M, UMR 5295, CNRS, Univ. Bordeaux, Talence, France)

5. Duration and credits

6 hours per week, divided into three days, for four weeks. Total of 24 hours. 5 CFU

6. Period and registration procedure

May 23rd – June 17th, during the visit of the lecturers at DICCA

7. Deadline for registration

Registration via email to be sent to alessandro.bottaro@unige.it; *last-minute students* will be accepted.

8. Final exam

The final evaluation will be based based on group projects, under the guidance of the instructors.