## Numerical Simulation in Applied Geophysics. From de Messocale to the Macroscale. MA59800

Professor: Juan E. Santos

## **Outline of Course Contents**

1) Review of the Finite Element Method. Description of some finite element spaces in 1D, 2D and 3D. Mixed finite element spaces methods for solving elliptic and Maxwell equations.

2) Derivation of the constitutive relations and equations of motion for fluidsaturated porous media (Biot's media). Relation with Darcy's law and thermodynamic considerations.

3) Determination of the coefficients in the constitutive relations and the viscodynamic coefficients in Biot's equations of motion in terms of the properties of the individual solid and fluid phases.

4) Determination and analysis of the phase velocities and attenuation coefficients for the different types of body waves propagating in Biot's media.

5) Solution of elliptic problems using finite element methods.

6) Numerical solution of Biot's equations of motion using the finite element method in the 1D and 2D cases. Global and iterative parallelizable domain decomposition finite element procedures.

7) Extension of Biot's theory. Cases of composite coupled solids and immiscible saturant fluids. Applications.

8) Definition of numerical upscaling procedures in a Biot's medium to determine an equivalent anisotropic viscoelastic media at the macroscale. Application to wave propagation in patchy-saturated and fractured Biot's media.

## Description of Some of the Homework Assignements

1: Calculation of the static and dynamic coefficients in Biot's equations of motion for some fluid-saturated porous solids.

2: Calculation of the phase velocities and attenuation coefficients for fluidsaturated porous materials.

3: Numerical simulation for 1D wave propagation in Biot's media using the finite element method. Application to the analysis of attenuation and dispersion effects in partially saturated and fractured porous media.

4: Numerical simulation of 2D wave propagation in Biot's media. Serial and parallel implementations.

5: Computer implementation of numerical upscaling procedures in Biot's media. Aplication to seismic monitoring in  $CO_2$  sequestration sites.

## References

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