

**Centre des Etudes Doctorales Sciences et Techniques  
&  
Sciences Médicales**

**THESIS DEFENSE**

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**CANDIDATE FOR DOCTOR SCIENCES AND TECHNIQUES**

**Study of Synovial liquid using Lattice Boltzmann Method**

<b>Date :</b>	<b>Saturday, January 20<sup>th</sup>, 2024</b>
<b>Time :</b>	<b>10.00 am</b>
<b>Location :</b>	<b>Conference Room, Building F, FST - Tangier</b>

**Committe Members**

Pr. Abdessamad AOUNI	FST - Tangier	Chair
Pr. Abdelmajid ALMAGGOUSI	FST - Marrakech	Reviewer
Pr. Soufiane DERFOUFI	FST - Tangier	Reviewer
Pr. Mohamed ZANOUNI	FST - Tangier	Reviewer
Pr. Abdelhadi ABOUNADI	UCA- Marrakech	Examiner
Pr. Adil CHAHBOUN	FST- Tangier	Supervisor

## ABSTRACT

Numerical studies of the mechanical and rheological behavior of systems related to human physiology play a significant role in various fields of bioengineering and medicine. For example, modeling cardiovascular systems and cardiac muscle, as well as the field of neurology modeling, has become a standard element in modern medical investigations. For these reasons, fundamental research on biological systems plays a crucial role in future medical treatments and the development of bioengineering. To this day, the origin of certain joint diseases has not been fully understood. The cause of osteoarthritis, for example, remains unknown; it is the aging nightmare for 15 million people suffering from osteoarthritis in France. While this condition affects one in two people after the age of 50, according to the United Nations, by the year 2050, 315 million people will suffer from symptomatic osteoarthritis, of which 105 million will face significant disability due to the disease. Doctors cannot repair the worn and sometimes disappearing cartilage. Research on osteoarthritis continues in an attempt to understand the causes of this chronic and painful disease. Synovial fluid is an essential means for the perfect mechanics of human joint lubrication, allowing bone sliding with very low friction coefficients and supporting loads it cushions. It behaves overall like a viscoelastic fluid due to the presence of hyaluronic acid molecules. These viscoelastic characteristics could be a significant improvement in the treatment of the disease. We focus on understanding the mechanisms related to human mobile joints, specifically the mathematical (digital) and mechanical description of the evolution of synovial fluid under stress (stress effects, temperature gradients, permeability, viscosity, etc.) using the Boltzmann lattice numerical method. We have addressed this topic in four chapters. In the first chapter, we provided more details on the origin of the Boltzmann method and its fundamental principles, as well as various techniques for improvement and simplification proposed by several researchers. The second chapter focuses on the dynamic study of the flow of a Newtonian fluid confined in a two-dimensional cavity with the upper wall subjected to sinusoidal motion. This chapter also explores thermal aspects, including heat transfer by mixed convection driven by temperature gradients and periodic wall movements. In the third chapter, we interpret the results of dynamic and thermal studies involving non-Newtonian fluids with the aim of understanding the behavior and evolution of synovial fluid (non-Newtonian). Finally, in the fourth and last chapter, we simulate the role of articular cartilage as a porous medium inside the cavity on the flow of non-Newtonian fluids and heat transfer rates. All the results presented in this work were obtained using code developed in Matlab.