Preface

This book is dedicated to the use of the finite elements method for the approximation of equations having partial derivatives. It resumes part of the curriculum leading to the certificate in "Numerical Methods for Mechanics" taught by the author since the past twelve years as part of the graduate studies in Mechanics at the University of Pierre and Marie Curie (Paris VI).

Numerical Analysis has undergone a spectacular development during these past forty years. It is most probably related to the boom in Information Technology which has literally invaded the planet and provided, *de facto*, calculation capacities undreamt of up to now.

This mathematical knowledge field – Numerical Analysis – may be characterised as the "mathematic of mathematics" in the same line of thought as that of a "police of polices".

Indeed, as soon as a mathematical technology cannot be applied within the industrial applications due to operational inadequacy, numerical analysis takes over and finds the solution by identifying the best adapted approximation process.

From there on, all other mathematical branches may be used to "force a passage" and to estimate a solution by often combining shrewdness and lucidity within a stringent mathematical framework.

Numerical analysis is best and most often applied to the approximation of equations having partial derivatives as a major support to the modelling of real systems.

Whether it be applications in physics or in mechanics, in economy, marketing or in the field of finance, the phenomenological translation of the system under study often leads to the resolution of equations having partial derivatives.

This justifies the invention of numerous methods to solve such equations. The finite elements method, the finite volumes method, the singularity or integral method, the spectral methods and the variational finite differences method are some of the most popular methods.

However, the finite elements are those that definitely and drastically changed the world of numerical approximation of equations having partial derivatives. Having an exceptional flexibility, the finite elements undoubtedly constitute the approximation method that is mostly used in solving mathematical models in engineering sciences.

Considering the mathematical technicality required to apply finite elements, many authors specialised in numerical analysis, including Pierre Arnaud Raviart (8), presented the subject at higher level university teaching reserved to students who possess the mathematical prerequisites, particularly in function analysis, essential for the theoretical initiation to the finite elements method.

Other student populations who have followed a curriculum not specialised in mathematics – specially graduate and postgraduate students in Physics or in Mechanics and the Graduate Engineering Schools who are users of the mathematical tool at different degrees – may get recourse to Daniel Euvrard's (5) book which was written in the 90's and that offers a version of a course adapted to students who are unfamiliar with the tools for functional analysis.

The superiority of those two manuals reflects the quality of the teachings of Numerical Analysis by Pierre Arnaud Raviart and subsequently by Daniel Euvrard at the Training and Research Unit in Mechanics of the Pierre and Marie Curie University.

As far as this piece of work is concerned, its necessity and its core content have been greatly influenced by the strong interaction between components of the author's teaching activities in mechanics, at graduate level, consisting of Numerical Methods applied to Mechanics and to the mechanics of deformable solids at the Pierre and Marie Curie University.

Indeed, the author was motivated by the will to pursue the initiative set by the two authors mentioned above by contributing to a new balance between a selective specialist reading and one dedicated to "operational aspects while skimming over the mathematical aspects", as stated by Daniel Euvrard ([5], p.198).

The author's training and awareness on all topics dealing with numerical analysis was greatly influenced by Professor Gérard Tronel, a specially active and passionate member of the team teaching numerical analysis at the Jacques Louis Lions laboratory of the Pierre and Marie Curie University (Paris VI).

The author benefited from Professor Tronel's significant educational methods and experience as a student and, later, as a colleague and friend, in bringing about the new balance offered in this book.

The author's warm thanks are conveyed to him for his contribution.

Graduate students in Mechanics of the Pierre and Marie Curie University are the ones who have followed this novel presentation within the framework of unidimensional applications of the resistance of materials.

The present work takes up these examples again and extends them to other applications.

Having identified targeted tools for functional analysis, as exposed without any demonstration, the problems dealing with the existence, uniqueness and regularity of weak solutions and their equivalence with strong solutions have been examined through the display and use of the result of this identification.

Following this perspective, the present work is composed of a Summary of Courses on finite elements in addition to Daniel Euvrard's [5] work, and of various solutions demonstrating these techniques of functional analysis while, at the

same time, tackling the construction of nodal equations characteristic of numerical implementation of the finite elements method.

Moreover, a special emphasis has been laid on the presentation of the application of assembly techniques illustrated in the problems related to the Resistance of Materials.

The author seizes this opportunity to pay tribute to the memory of Claude Kammoun who initiated him to these techniques within the framework of Resistance of Materials.

Finally, this work would never have been published without Benoît Goyeau and Cédric Croizet's proofreading of the different examination subjects at graduate level Mechanics that constitute a major part of this book. The author conveys his sincere thanks to both of them also to Dr. Arnaud Chauvière for his efficient advices in Latex Programmation.

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