Bellomo, Nicola , Elena De Angelis, and Marcello Delitala. 2007. *Lecture Notes on Mathematical Modelling in Applied Sciences, Lecture Notes*. 168 pp.

See https://staff.polito.it/marcello.delitala/dwd/mechanic_Simai.pdf . Accessed 27 March 2023.

From the Opening of the Notes:

The Lecture Notes collected in this book refer to a university course delivered at the Politecnico of Torino to students attending the Lectures of the master Graduation in Mathematical Engineering.

The Lectures Notes correspond to the first part of the course devoted to modelling issues to show how the application of models to describe real world phenomena generates mathematical problems to be solved by appropriate mathematical methods. The models dealt with in these Lecture Notes are quite simple, proposed with tutorial aims, while relatively more sophisticated models are dealt with in the second part of the course.

The contents are developed through four chapters. The first one proposes an introduction to the science of mathematical modelling and focus on the three representation scales of physical reality: microscopic, macroscopic and statistical over the microscopic states. Then, the three chapters which follow deal with the derivation and applications of models related to each of the afore-mentioned scales.

As it is shown, already in Chapter 1, different mathematical structures correspond to each scale. Specifically models at the microscopic scale are generally stated in terms of ordinary differential equations, while models at the macroscopic scale are stated in terms of partial differential equations. Models of the mathematical kinetic theory, dealt with in Chapter 4, are stated in terms of integro-differential equations.

The above different structures generate a variety of analytic and computational problems. The contents are devoted to understand how computational methods can be developed starting from an appropriate discretization of the dependent variables.

The Lecture Notes look at application focusing on modelling and computational issues, while the pertinent literature on analytic methods is brought to the attention of the interested reader for additional education. After the above introduction to the contents and aims of the Lecture Notes, a few remarks are stated to make a little more precise a few issues that have guided their redaction.

All real systems can be observed and represented at different scales by mathematical equations. The selection of a scale with respect to others belong, on one side, to the strategy of the scientists in charge of deriving mathematical models, and on the other hand to the specific application of the model.

Systems of the real world are generally nonlinear. Linearity has to be regarded either as a very special case, or as an approximation of physical reality. Then methods of nonlinear analysis need to be developed to deal with the application of models. Computational methods are necessary to solve mathematical problems generated by the application of models to the analysis and interpretation of systems of real world.

Computational methods can be developed only after a deep analysis of the qualitative properties of a model and of the related mathematical problems. Different methods may correspond to different models.

Modelling is a science which needs creative ability linked to a deep knowledge of the whole variety of methods offered by applied mathematics. Indeed, the design of a model has to be precisely related to the methods to be used to deal with the mathematical problems generated by the application of the model.

These Lectures Notes attempt to provide an introduction to the above issues and will exploit the use of electronic diffusion to update periodically the contents also on the basis of interactions with students, taking advantage of suggestions generally useful from those who are involved pursuing the objective of a master graduation in mathematics for engineering sciences.

Keywords: modelling, differential equations, applications, spring mass, numerical methods, Legendre polynomials