

Preface

Engineering and Physics cannot be thought of without models; models, which represent the real world to the best of our knowledge. And before we start with any mathematical description, with any mathematical model, we have to establish something like a phenomenological picture, a symbolic map of the real-world structures with elements like masses, springs, dampers, fluid system, thermodynamic elements and so forth and, not to forget, with elements of interconnections frequently more complex than the elements themselves.

This very first step of physical or mechanical modeling is mostly underestimated, but it decides very substantially about the success of all following activities like mathematical modeling, numerical algorithms, and finally computer codes. Therefore, it is worth looking at that more systematically, in spite of the fact that there does not exist any systematic approach to these problems. It is still more an art than a science.

Good modeling requires a deep insight into the performance of the real-world artifact, may it be a machine, an airplane, or human walking. We must understand how it works, in terms of operations, functions, dynamics, kinematics, stability and deformation, noise and wear, and even costs. But this is only one important precondition. Other aspects are the goals and requirements connected with such models.

First, there are the simple models, which nevertheless represent the main features of a problem, for example of a vibration problem, in such a good way, that they can be used to give some analytical insight into that problem with regard to dynamics but also with regard to parameter influences. Establishing such models is an art for a very few number of experts. It requires a perfect knowledge of the specific problem under consideration, and it affords intuition and intelligence to reduce such a system to a few parameters. But we often can learn from such models in a couple of days much more than by long-lasting computer simulations.

Second, we may establish models by considering as many details as possible. Such models are large and costly regarding computing times. And even in this case we have to investigate very carefully all physical effects for doing the correct neglects without endangering realistic results. Done in a skillful way such models

are the basis for physical understanding and for improving design concepts. These two types of models aim at generating some results, which are as realistically as possible related to our real-world problem.

Third, if we leave that requirement, we may find models with similar features as our real-world case, but only in a more or less qualitative sense. This might help sometimes, but usually it is too far away from practice. Anyway, establishing models includes very strong phenomenological issues. This is mostly underestimated, because only good models in a mechanical sense, at this stage not in a mathematical sense, give access to good solution algorithms and finally to good results. Models should be as simple as possible and so complex as necessary, not more and not less.

As a rule we understand the word model as a theoretical construct. But model and modeling applies in the same way to experimental setups. Lack of thought very often identifies experiments with the dogmatic truth of practice, which is only sometimes true. To design and to establish good experiments really related to the practical system under consideration is a difficult task. And it is also a difficult task to find the correct interpretations of measured data. Therefore, comparing theory and measurement requires very much care on both sides, on the side of theory and that of experiments.

From all this we know, that modeling mechanical, and generally physical systems, requires insight and intuition, which usually is connected with long and broad professional experience. The course concerned with such a topic aims at presenting some rules for mechanical models in a more general systematic way always in combination with small and large examples able to illustrate the most important features of modeling. It will be not a course presenting mathematical solution algorithms, but discussing more advantages and disadvantages of potentially well-suited mathematical branches. It is a course with a strong focus on the art of modeling.

The following lectures have been given:

- Hartmut Bremer, Fascination of Making Models
- Friedrich Pfeiffer, Model Objectives and Realization
- Michel Raous, The Art of Modeling in Contact Mechanics
- Ahmed Shabana, Flexible Multibody System Dynamics
- Steven Shaw, Modeling for Nonlinear Behavior in Dynamics Systems
- Peter Wriggers, The Art of Modeling in Computational Mechanics

These lectures cover aspects of dynamics and also, to a certain extent, of continuum mechanics. They demonstrate, that the modeling problems have very much in common with respect to various fields, but of course with differences from the structural point of view. In the following these lectures will be presented in text-form.

Garching, Germany
Linz, Austria

Friedrich Pfeiffer
Hartmut Bremer

The Art of Modeling Mechanical Systems

Pfeiffer, F.; Bremer, H. (Eds.)

2017, VII, 386 p. 196 illus., 71 illus. in color., Hardcover

ISBN: 978-3-319-40255-0