Postscript

THE PITFALLS OF MODELLING AND ADVICE FOR A MODELLER

Since mathematical modelling is a multi-stage activity requiring a variety of concepts and methods, there are many pitfalls which can lead a modeller to produce wrong models and therefore absurd solutions to the original problem. In this section we focus our attention on these pitfalls of modelling, giving at the same time some comments and advices to avoid them.

As we see in many instance, although in the process of complex mechanical system modelling we refer to results obtained in numerous branches of physics and mathematics, the process itself is not subject to strict formalization, which makes modelling an even more intricate activity. An important aspect in this is the inexperience of a scholar, which, in turn makes pitfalls more frequent in view of the subjectivity thus involved.

It appears that the most frequent error consists in too strong an attachment to a certain theory or to a concrete model, such as the tendency of describing everything that flows by means of the Navier–Stokes equation. We are putting forward this kind of error, remembering the responsibility of a scientist for his actions. It is true, in reality alas, that the human mind displays a greater tendency towards assessing almost all things on the basis of one's own experience, knowledge and established opinions than on the basis of the evidence presented.

Some of the main pitfalls which the model builder should be aware of are listed below:

(1) Forgetting that modelling should serve some purpose and therefore that there must be a goal to modelling. Lack of awareness of this requirement makes it more difficult both for the modeller to do the work and for others to follow the reasoning in the scientific publication resulting from it.

(2) Forgetting that the pragmatic aim of modelling is to produce the simplest adequate mathematical model. Quite frequently a simple mathematical model based upon rational foundations yields more than a model which is refined but devoid of solid foundations.

(3) Lack of distinction between assumptions in the physical model and simplifications in the mathematical one. While the former should have an empirical basis, the latter

are justified by the need to obtain simpler solutions. The permanent awareness of the type of simplifications enables an easy improvement of the model.

(4) Failure to check a model in terms of the sensitivity of the response to changes in parameter values. If the model is highly sensitive, then it is of limited use for prediction purposes.

(5) Forgetting that a model is only a simplification of the real world associated with the problem, and the model obtained cannot have any solution. This pitfall results in a deep belief that the solution to the model exists only because the model was formed for a phenomenon, of which we know that it has some real course.

(6) Conviction that obtaining of solution is just a question of accessibility to a computer having adequately large capacity and speed of operation. This pitfall may result in producing an immense amount of numbers, whose interpretation can be difficult or even wrong.

(7) Tendency towards giving preference to the expected results. When a modeller has done everything possible to avoid prejudices in the model proposed by himself, he can always refer to a friendly criticism of colleagues.

(8) Forgetting that a model is nothing but a model, and that its construction may be subject to errors, so before delving into the whirl of computer calculations one should very carefully study assumptions taken and try to predict the qualitative features of solutions to the model, such as stability.

(9) Unawareness that a model can be accepted as an adequate model only when it has passed the verification test. As long as the model has not been tested, the modelling cannot be regarded as complete.

(10) Loss of an inspection of the entire modelling problem when going into calculational details. In order to produce an adequate model of a complex mechanical system one requires a wide understanding of many different topics. Sometimes one needs even collaboration with people of different backgrounds.

In reality there are many doubts and even errors before the modeller reaches a satisfactory model. It is good to learn of several setbacks suffered by great exponents of mathematics and mechanics, as a warning and ... comfort.

FINAL REMARKS

Although we are reaching the end of this volume, we do not think that we have said everything about forming discrete models of complex mechanical systems. We have said nothing about various kinds of equations of analytical mechanics, such as Hamilton's (1834) or Kane's (1961), to recall just those best known. Neither have we presented such popular modelling tools as the finite element method or the bond graph method.

Moreover, we have not even given definition of a complex mechanical system. Let our justification be an analogous difficulty, with the answer to the question 'what is Physics?'. The facetious answer to this question given by Feynman is: 'physics is all that physicists think about when they can not sleep at night.' Similar, though not equally

witty, is our answer to the question posed above: complex mechanical systems are those of the type considered in this book.

Finally we would like to emphasize that the main efforts have been directed to provision of a rational approach to mathematical model creation and not to provision of a great diversity of modelling methods. **György Polya**, the author of the famous book *How to Solve It*, said that in gaining knowledge it is more important *how* we teach than *what* we teach. We absolutely agree with him and that is why we have not tried to increase the amount of concrete information, but we have endeavoured to familiarize the reader with a rational methodology of mathematical model creation and with three fundamental modelling methods—the balancing, variational and topological methods. We believe that the reader who as acquired these methods will be able to familiarize himself with any other particular modelling method suitable for the specific problem.

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