

REALITY AND ITS REPRESENTATION

A guide to the scientific method and the mathematical modeling of physical and engineering systems

Held by
Daniele TESTI, PhD
Full Professor of Thermal Science and Engineering

Venue: Biblioteca “Lorenzo Poggi”, DESTEC, Polo A

Date: 8 hours

Friday, March 1st 2024, 3:00 p.m. - 5:00 p.m.

Friday, March 8th 2024, 3:00 p.m. - 5:00 p.m.

Friday, March 15th 2024, 3:00 p.m. - 5:00 p.m.

Friday, March 22nd 2024, 3:00 p.m. - 5:00 p.m.

Abstract

If discovering the intimate nature of the reality that surrounds us is a conceptually insidious and way too ambitious goal, no epistemological rule halt us from giving a mathematical representation of it. Doing so, relevant attributes of reality are distilled from the whole picture, generating a microcosm that is simpler, functional, and tailored to answer no more and no less than the question that was initially posed and motivated the entire research path. This process and its final output in the form of quantitative equations is what in science and engineering we call a model. The model becomes a tool to analyze, interpret and predict the behavior of an otherwise too complex object or phenomenon. On top of simplicity and usefulness, it must possess some additional qualities such as objectivity, consistency, reproducibility, verifiability, flexibility, reliability. Besides, its boundaries and uncertainty must be well clear to both creator and user.

Modeling is such a ubiquitous and essential activity that every researcher, consciously or not, continually strives to resort to it in its endless quest for knowledge and application. Unfortunately, developing a good model is hardly an easy task and requires a deep understanding of the problem under scrutiny, often built on experience and observation, and also a bit of intuition and fantasy for creating the appropriate abstraction. No book can teach you how to handle your specific modeling case, but at least the scientific method will be a guide to follow; then, exercise and analogy will do the rest.

Far from being exhaustive, this short course will attempt to classify the types of models and modeling approaches and the necessary steps for their development in the overarching framework of the scientific method. In addition, hints will be provided to discover the presence of structure and causal relationships between variables, and notable problems from the science and technology world will be examined, suggesting different solutions to the same problem at an increasing level of detail, gradually encompassing wider scopes at the expense of a higher computational effort and a decreased handiness and interpretation potential of the tool. Proactive in-class discussion will be encouraged, to favor conscious reasoning in the development phase leading to model proposals.

Agenda

Day #1

Statement of the scientific method in modern terms

Day #2

Classification of mathematical models and modeling approaches

Day #3

Description and guide to the model development process

Day #4

Examples of models suitable for relevant physical and engineering systems