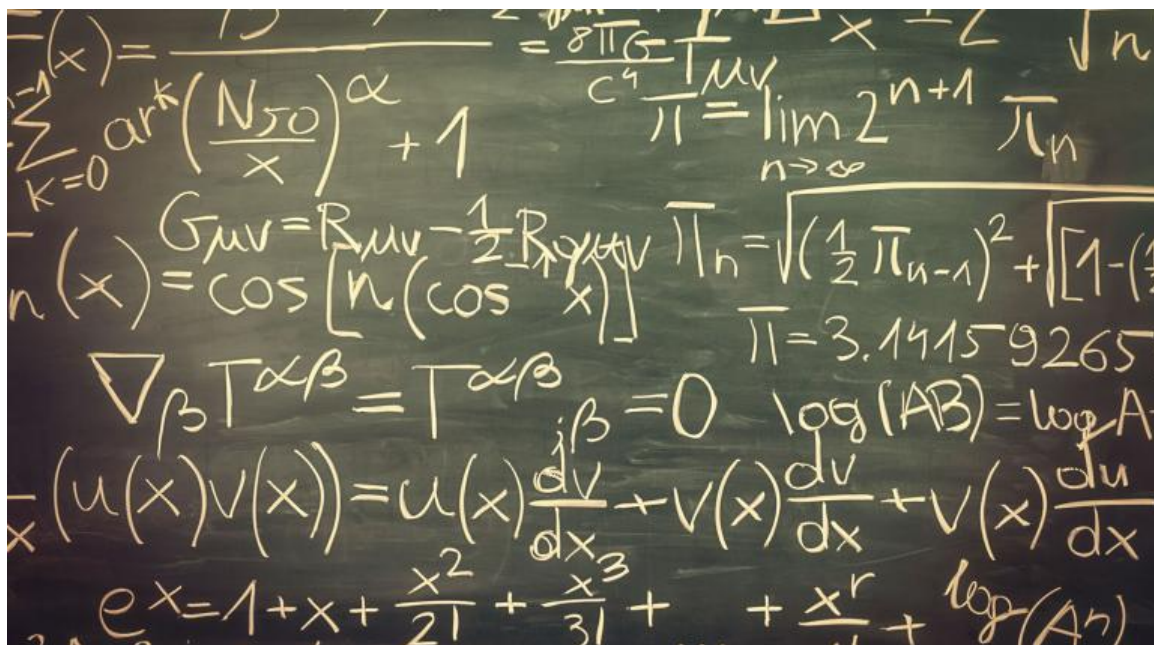# ENGINEERING MATHEMATICS AND SCIENTIFIC COMPUTING WITH SymPy, NumPy and SciPy

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This book is dedicated to the memory of

Professor Anadi Sankar Gupta

former Head of Department of Mathematics,

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who instilled in me a passion for mathematics.

Preface

"The language God talks" is a phrase attributed to Richard Feynman, the distinguished Nobel Prize–winning physicist, as an encouragement to learn calculus. Mathematics, indeed, is the language of science. Centuries earlier, the Italian astronomer and physicist Galileo Galilei declared, *"Mathematics is the language in which God has written the universe."*

In 1865, James Clerk Maxwell, a Scottish mathematician at Cambridge University, published his seminal work that unified electricity, magnetism, and optics through a set of elegant equations—an achievement that transformed modern civilization. Albert Einstein once remarked, *"The work of James Clerk Maxwell changed the world forever."* Maxwell was a consummate mathematician. The tools he employed had been developed a century earlier, but he used them to synthesize the experimental findings of Michael Faraday and others into a coherent mathematical framework.

Mathematics enables us to explore the connection between creativity and structure. Creativity flourishes within mathematical formalism—it sharpens critical thinking and cultivates the art of problem solving. We should study mathematics for the same reason we study art, literature, history, or science: it represents one of humanity's highest intellectual achievements. The works of Newton, Gauss, Leibniz, and Ramanujan in mathematics stand beside those of Tagore, Shakespeare, and Leonardo da Vinci in art. Too often, mathematics is appreciated only for its utility and seen merely as a toolbox. In truth, it is much more than that. Understanding mathematics should be a universal pursuit, not confined to students of science and engineering. Mathematics teaches us to be objective, quantitative, and precise in our expression, while the process of problem solving nurtures patience and resilience.

This book is intended to introduce students of engineering, physics, mathematics, computer science, and related fields to a coherent set of mathematical concepts required to tackle real-world problems. Given that curricula are already dense and time is precious, this volume provides a crisp and concise exposition of fundamental ideas in engineering mathematics essential to understanding both natural and engineered phenomena. It is described as a *handbook* because it is designed as a ready reference—concise yet complete, with concepts accompanied by their proofs.

A common misconception about mathematics is that it is a talent one is born with. In reality, success in mathematics depends far more on one's approach to learning and practice than on innate ability. Like any other skill, proficiency arises through sustained effort.

> With the advent of symbolic computation, much of the traditional drudgery has been eliminated. Throughout the book, examples are illustrated using *SymPy*, *NumPy*, *Python*, and *JupyterLab* to help visualize solutions. In this respect, the book takes a somewhat distinctive approach.

The author is a retired software executive with a deep interest in quantitative methods. He holds a Doctor of Science and a Master of Science degree from the Massachusetts Institute of Technology (MIT), following his undergraduate studies at the Indian Institute of Technology (IIT) Kharagpur.

I hope you enjoy reading this book and that it inspires you to develop a lasting appreciation for the beauty and power of mathematics.

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