Making Sense out of Engineering Modeling and Mathematics

The Maplesoft vision for engineering education
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Built on over 20 years of success and experience in high performance mathematical computing, Maplesoft has introduced a new product line designed to face the challenges of modern engineering head on. The Maplesoft product vision delivers advanced modeling techniques that increase research efficiency by an order of magnitude but is so easy to use and intuitive that undergrads can easily manage its power and gain greater insight into the nature of physical system modeling.

The benefits to the institution are fundamental. Whether your interest is in the classroom experience, or advanced theoretical research, or practical realizations of designs, or even development of sophisticated models for consulting services to industry, the Maplesoft product line uniquely provides tools to satisfy such different needs. Practitioners across a broad spectrum of engineering, including challenging fields such as hybrid-energy systems and next-generation space systems have already endorsed the Maplesoft vision. To these leading organizations, Maplesoft represents major steps ahead of the current norm in engineering simulation.

Introducing MapleSim

Principal among its new modeling products is MapleSim – the world’s first high-performance, physical, modeling system employing advanced symbolic technology for automatic equation generation, model simplification, and parameter management. These advanced algorithms produce models that are simply faster and more useful for the academic world than any other available engineering modeling software system.

MapleSim adds an exciting new dimension to engineering modeling: the ability to quickly and intuitively define physical models. Its interactive drag and drop paradigm, and physical component world view greatly amplifies all of the benefits of Maple. Whereas Maple has an arguable conceptual advantage on the general analytical side, MapleSim anchors the discussion in a physically meaningful and visual environment. Systems are represented as configurations of real components. Conversely, today’s signal-based simulation tools use a highly abstract block diagram framework little changed from the days of the analog computer.

In addition, MapleSim is natively multi-domain, readily adaptable to emerging fields such as mechatronics and hybrid energy system modeling. The symbolic power of MapleSim automatically generates equations of motion so critical in study of any sort, and provides simplification tools to ensure that resulting simulations are as fast as possible, supporting demanding applications such as real time simulation.

“Maple made the entire design process easier and faster – what used to take weeks we did in a few days”.

Dr Richard Gran, Director (rtd), Advanced Concepts Laboratories, Grumman, Maglev Control Project
MapleSim and Maple provide a complete software solution for engineering modeling in research and teaching. In addition to the comprehensive suite of built-in tools, both systems offer direct connectivity to a wide range of critical engineering tools: from CAD systems, to MATLAB® and Simulink®, to NI Labview and NI Veristand, to Web data sources, and more.

Maple stands apart from all other engineering software, including its own predecessors, with a rich set of unique features specifically for engineers. They include:

- A library of functions for dynamic system modeling that provides the tools to describe models (including DEs, transfer functions, state space models, etc.), perform analysis (including generalized root locus, frequency response, time response, etc.), and even optimize designs.

- Bi-directional connectivity with popular CAD systems allows you to perform a wide range of system-level calculations and analysis on your drawings without resorting to the expense or complexity of FEM solvers.

- Rich unit and dimension management. Whether it is simple conversion or complete management of all your units in complex calculations, Maple’s unit management feature provides the ideal framework to prevent disastrous calculation errors.

- Vast library of solvers for engineering application areas: differential equations, matrices, transforms including FFT, statistics, wavelets, and more. In all over 3000 mathematical functions ensure any analytical goal is often only a function away.

A concrete response to industry trends

In 2007, Maplesoft announced a major agreement with the Toyota Motor Corporation to collaboratively build a new generation of engineering modeling tools for physical systems [1]. This initiative is in response to a growing concern within industry about the ability of the current generation of modeling and simulation software to meet the emerging design challenges.

Of particular concern was the inordinate efforts needed to develop good models for complex physical systems such as mechatronic or multibody dynamic models. Even in this age of software automation, engineers spend days and weeks in

The essential technical computing software for today’s engineers

The name Maple is synonymous with intelligent technology to reduce the burden of manual mathematics. Generations of faculty and students have relied on its symbolic, numeric, graphic, and programming power to bring their academic endeavors to unprecedented levels.
painful, error-prone processes to formulate appropriate model equations.

This problem is real and it is universal across virtually all industries. Without the right tools, Toyota felt that its ability to innovate would be severely limited.

The answer for Toyota and so many other leading companies was simple: the math matters and we need to increase the modern engineer’s ability to manage more complex and rigorous mathematical models and analytical techniques. With the right tools, any organization can move beyond the stifling limitations of current tools.

In response, Maplesoft has invested heavily in developing a new generation of modeling technology specifically designed for engineering modeling. Though best known for its contribution to mathematics research and education, it applied its experience and its technology portfolio to deliver a new generation of engineering tools. The common design principles behind all our products include:

- Symbolic manipulation to automatically derive error-free model equations.
- Advanced mathematical techniques that are accessible to a broader class of engineers and even undergraduate students.
- Extensive connectivity to many industry standard tools to ensure analytical rigor in all stages of modeling.

MapleSim and Maple reflect today’s industrial reality, delivering the modeling flexibility to manage more sophisticated model formulations and provide maximum performance.

**A new foundation for engineering mathematics and modeling**

MapleSim and Maple manage not only the numbers of engineering but all of the analytical concepts and theoretical knowledge. Unique among engineering software, they provide an integrative approach to model development and simulation.

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"Automotive companies like us will realize further improvements in cycle times, cost optimization, and smoother implementation of extremely complex systems."

Mr. Akira Ohata: Project General Manager, Toyota Motor Corporation

Traditional numeric matrix systems or signal-based simulation systems that are currently very popular in engineering modeling and simulation are fundamentally “downstream” tools: once the ideas are formulated, they help you with the final steps of simulation and realization.

In a recent survey of thousands of engineers [2], it was found that more than 50% of modern engineers still reach for manual, error-prone tools such as pencil and paper to deal with the necessary mathematics for effective modeling. It is only when this manual process is complete that the computer can be utilized to streamline the process.
The Maplesoft view is fundamentally different. Mathematics is an essential medium that flows through all steps of engineering design whether in industry, research, or education. The effective, consistent management of engineering mathematics throughout the project can dramatically reduce your project time and improve your results.

**Meaningful benefits in the classroom**

Although the Maplesoft engineering solution is gaining wide acceptance within industry, its potential in education is just as significant. In many ways, the Maplesoft engineering suite is what engineering professors have always wished for: a platform where students can work confidently with everything from theoretical concepts to the subtleties and art of design, all within an intellectually rigorous framework.

**Focus on concepts and not manual solution steps.** The symbolic abilities of Maplesoft technology are well known. With intelligent algorithms for symbolically solving differential equations, transforms, and countless specialized operations, students can focus on the meaning and application of these powerful concepts and not regurgitate the steps of a recipe.

**Connect the concepts.** The solution addresses one of the age-old problems in engineering education: the disconnect among various courses due to differences in curriculum, pedagogy, and even notation. With Maplesoft tools you can quickly move from one analytical framework to another without paying the penalty of laborious hand manipulation. Connecting the concepts of calculus to differential equations to specialized fields including control, thermodynamics, multibody dynamics, and more are not just possible but highly effective.

**Equalization of mathematical skills.** By the time a student reaches his senior year, he or she should be synthesizing the great ideas and techniques of engineering, not wondering what trig substitution solves an integral or where the asymptote is for a certain function. Many bright capable students have what it takes to succeed with advanced concepts but may have had missteps in earlier courses. By removing the mechanics of mathematics, every student has a chance to succeed with the real objective of engineering education.

**Engaging presentations and explorations.** Something as mundane as drawing a decent graph of a function can make or break a learning experience. Maplesoft products are recognized for their extensive collection of easy-to-use interactive tools that make the presentation and manipulation of complex concepts quick and professional.

**Emerging industry standard.** For your institution to remain at the forefront of collegiate education, the tools you introduce to your students must reflect the changing realities of industry. Maplesoft’s innovative products have been recognized by leading companies in automotive, aerospace, electronics, and other industries as enabling technologies to advance the state of analysis and mathematics in engineering, moving beyond the incumbent tools that deploy software thinking of the 1970’s.

One of the most active fields to deploy the new view of engineering software is in the interdisciplinary field of control systems. With emerging engineering challenges such as alternative fuel vehicles, biomechanical engineering, and space applications, the need for more effective treatment of the mathematics, models, and simulation has never been greater.

Instructors use the Maple system to manipulate transfer functions, to compute Laplace and inverse Laplace transforms, plot responses, and perform advanced control analysis like root locus. More importantly, however, Maple allows students to finally see the intimate relationships among the differential equation (or state space) representation, the Laplace-domain transfer function representation, and frequency domain representations.

The Maple approach promotes design and application thinking using the theoretical concepts. Students can see first hand how notoriously abstract concepts such as characteristic equations, eigenvalues, poles and zeros, etc. have an impact on design.
Summary of the product line

Maple

Maple is the essential technical computing software for today's engineers, mathematicians, and scientists. Whether you need to do quick calculations, develop design sheets, teach fundamental concepts, or produce sophisticated high-fidelity simulation models, Maple's world-leading computation engine offers the breadth, depth, and performance to handle every type of mathematics.

MapleSim

MapleSim is a physical modeling tool unlike any other. MapleSim is built on a foundation of symbolic computation technology, which efficiently manages all of the complex mathematics involved in the development of engineering system models, including multi-domain systems and plant models for control applications.

Toolboxes and E-books

A series of powerful solvers, modeling aids, and electronic references, these add-on products quickly adapt the core system to specialized needs.

Testing and Assessment

A complete Web-based infrastructure to complete the educational deployment of Maplesoft engineering products. The Maple Testing and Assessment system is uniquely capable of supporting the particular challenges of automated testing in math, science, and engineering.

References and further reading


[2] Paper and Pencil = Modern Field?


