A New Generation of Software Tools for the Engineering Professional

Maplesoft™

Mathematics • Modeling • Simulation

A Cybernet Group Company

MapleSim™

The Modern Approach to Physical Modeling and Simulation

MapleSim™ dramatically reduces model development and analysis time while producing fast, high-fidelity simulations. It is a "white-box" Modelica® platform, giving you complete flexibility and openness for complex multidomain models. With MapleSim, you create, analyze, and run system-level models in a fraction of the time it takes with other tools.

Maintain full control with "white-box" modeling and analysis

MapleSim, coupled with Maple™, is a completely open environment, meaning that you are never restricted to built-in components or analyses. With its complete programming and analysis environment, you can run simulations, customize analyses or script entirely new ones, perform optimizations, develop advanced symbolic control laws, and investigate models in ways not possible with other tools. You can even create custom components right from their unsimplified governing equations – our solution does all the work to incorporate them into your model.

- Create custom components directly from their equations
- Easily script custom analyses
- Take advantage of the world's most powerful symbolic and numeric math engine
- View and manipulate system-level equations, even for multibody and multidomain systems

Get the fastest auto-generated code for real-time and optimization

Whether you are running 100,000 simulations during an optimization or executing in real-time for hardware- and software-in-the-loop testing, your model code must be fast. MapleSim produces the fastest auto-generated model code, and the code is completely royalty-free. You can achieve real-time the first time, without sacrificing fidelity in your system-level models. MapleSim's fast model code can be exported as

S-functions, making MapleSim the best physical modeling solution for Simulink®.

- Best core symbolics generates extremely fast model code
- No more hand-coding: save time and eliminate errors with automatic code generation for custom components
- Pass your work down the toolchain: provide downstream engineers with fast and accurate exported models, including S-functions, C code, FMI, and more

Give yourself a head-start on projects with a powerful Modelica platform

MapleSim is based on the open-standard Modelica modeling language, so you can leverage the growing collection of industry-tested Modelica components in your own projects. What's more, with Modelica, models and components are open and object-oriented, making them easy to reuse, customize, share, and extend to suit your exact needs. But MapleSim is more than just Modelica – it's Modelica "Plus", consisting of an entire platform for modeling, simulation, and analysis, where Modelica provides the component and model description.

- Open, object-oriented system-level modeling language
- Custom components that automatically generate corresponding Modelica code
- Flexible Modelica multidomain framework

"The MapleSim models we're running allow us to predict head delivery conditions with more variables, higher precision, and faster run times. Using MapleSim's simulation tools, we can generate custom swing calculations based on every equipment variable, leaving nothing to speculation."

John Rae, Research Manager, R&D, Cleveland Golf

MapleSim Add-ons

MapleSim Connector

High-performance, high-fidelity MapleSim models are automatically converted to S-Function blocks for seamless inclusion in Simulink® diagrams. The highly efficient S-Function blocks are suitable for fast execution within Simulink® and real-time implementation through Simulink® Coder™.

MapleSim Connector for LabVIEW™ and NI Veristand™ Software

High-performance, high-fidelity MapleSim models are automatically converted to user code blocks for easy inclusion in your LabVIEW VIs and NI VeriStand applications. The model code is fully optimized for high-speed real-time simulation, allowing you to get the performance you need for hardware-in-the-loop (HIL) testing without sacrificing fidelity.

MapleSim Connector for dSPACE® Systems

Streamline your development process by automatically converting your high-performance, high-fidelity MapleSim models into real-time applications running on the DS1104 R&D Controller Board.

MapleSim Connector for FMI

Export MapleSim models in a standard format established by the Modelica Association, which is easily understood by other FMI-compliant tools in your toolchain.

MapleSim Connector for VI-CarRealTime™

Incorporate high-fidelity, multidomain models created in MapleSim into the real-time vehicle simulation environment of VI-CarRealTime.

MapleSim Connector for B&R Automation Studio

Extend your B&R toolchain by integrating high-performance, multidomain system models from MapleSim into B&R Automation Studio.

MapleSim Control Design Toolbox

A solid set of essential control design tools that extend MapleSim's exceptional plant modeling capabilities to support control design. Included are tools for model linearization, PID tuning, development of state-space control strategies, and custom compensator design.

MapleSim Tire Library

Industry standard tire force components for Fiala, Calspan, and Pacejka's magic tire formula. In addition, linear and user-defined tire models are available.

MapleSim Driveline Library

Components, transmission sub-assemblies, and powertrain examples for driveline applications. Built with guidance from several transmission manufacturers, this library allows you to mix the best of physical models and empirical data to maximize model fidelity, optimize your designs, and improve overall vehicle fuel efficiency.
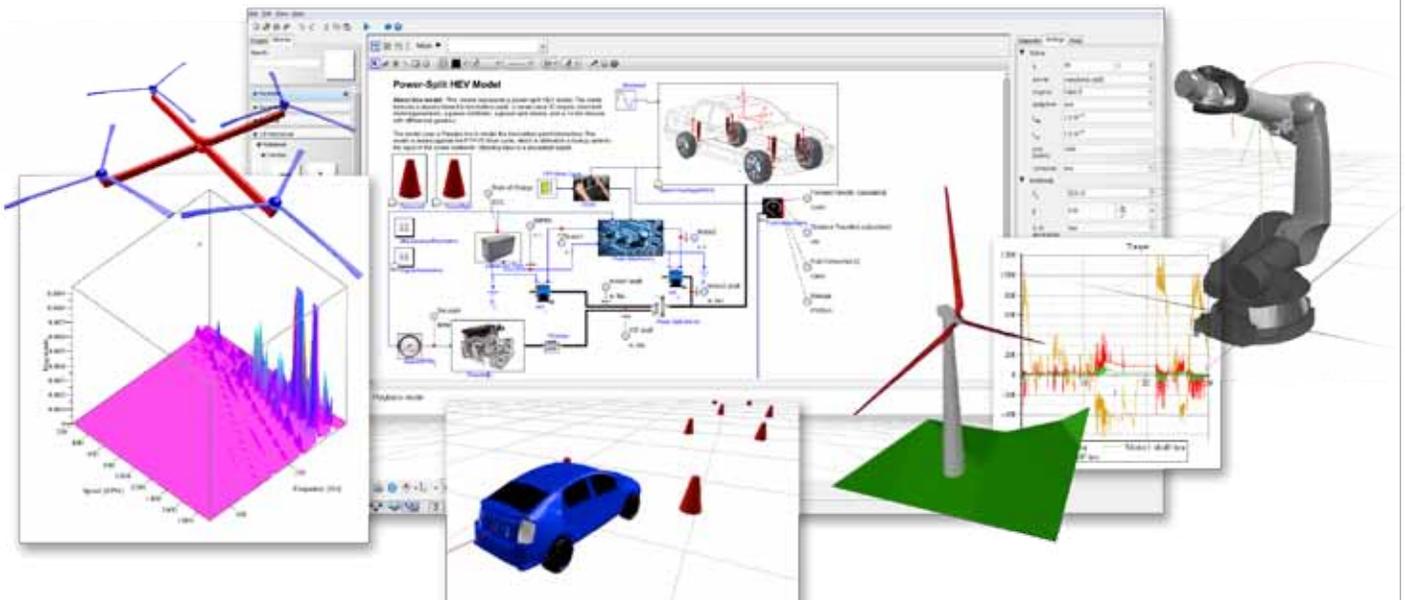
Maple™

The Essential Tool for Mathematics and Modeling

Mathematics plays a critical role in our modern world, which is why mathematicians, engineers, and scientists everywhere rely on Maple software. Maple helps you analyze, explore, visualize, and solve mathematical problems quickly, easily, and accurately. With over 5000 functions covering virtually every area of mathematics, Maple has the depth, breadth, and performance to meet all your mathematical challenges.

Most Powerful Math Engine

Whether you need to do quick calculations, develop design sheets, or produce sophisticated high-fidelity simulation models, the world-leading Maple computation engine provides the necessary technology to dramatically increase your analytical productivity.

- Over 5000 functions covering virtually every area of mathematics, including calculus, algebra, differential equations, statistics, linear algebra, geometry, and transforms
- Symbolic, numeric, and hybrid computation algorithms
- World-leading algorithms for solving problems that are beyond the reach of any other software system
- Efficient algorithms and tools for high performance computing and large-scale problem solving

Smart Document Interface

Maple's intuitive interface supports multiple styles of interaction, from interactive tools to a sophisticated programming language. Using the smart document environment provided by Maple, you can automatically capture all of your technical knowledge in an electronic form that combines calculations, explanatory text and math, graphics, images, sound, and diagrams.

- Easy-to-use math equation editor, interactive assistants, task templates, and self-documenting context-sensitive menus
- Sophisticated programming language
- 2-D and 3-D plotting and animation, with extensive annotation tools
- Extensive document creation and word-processing tools

Extensive Connectivity

Extensive connectivity features ensure Maple can be integrated seamlessly into your toolchain. Maple connects to standard engineering tools and custom solutions in a variety of ways.

- Code generation (C, C#, Fortran, Visual Basic®, Java™, MATLAB®)
- Connectivity to Excel®, MATLAB®, MapleSim, Java, Fortran, CAD systems, C, databases, web sites, and more
- Extensive import and export capabilities for data, documents, math, and plots
- Web deployment through MapleNet™

Application Areas

Differential Equations	Code Generation
Calculus	Units and Tolerances
Engineering	CAD Connectivity
Matrix and Vector Computations	Scientific Data Management
Algebra	Statistics and Process Control
Physics	String Processing and Linguistic Research
Visualization	Parallel and Grid Computing
Curve Fitting	
Optimization	Application Development
Financial Modeling	Web Deployment
Special Functions	
Advanced Mathematics	
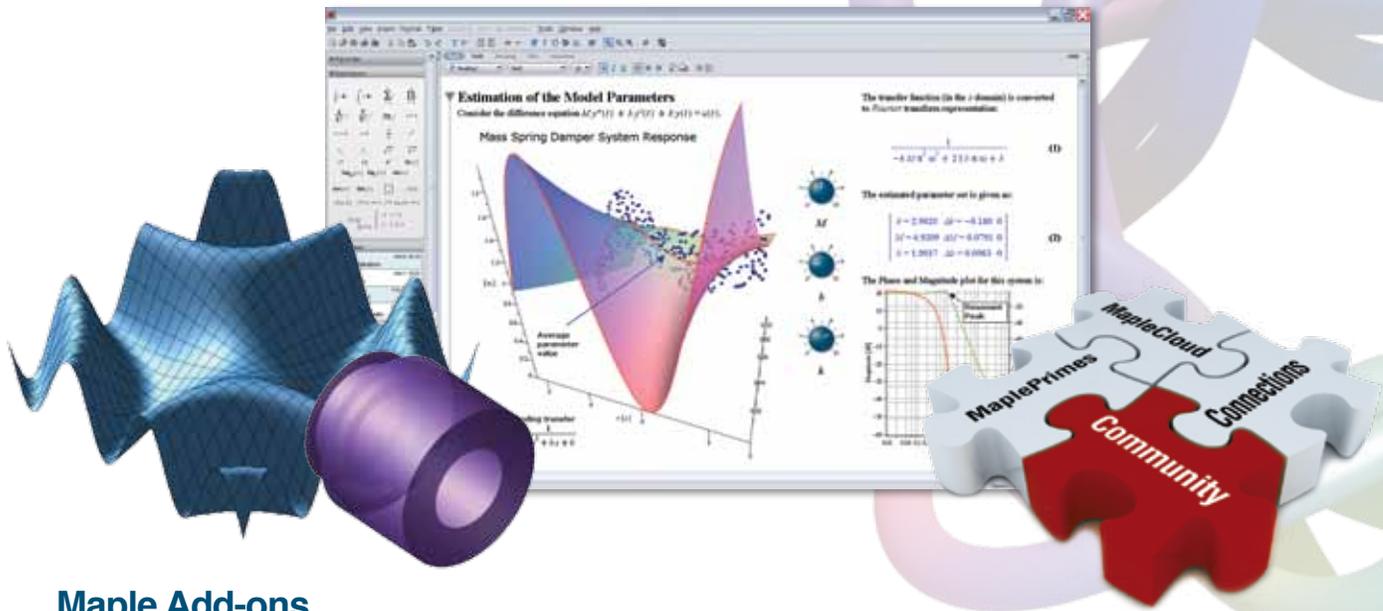
Maple Add-ons

Global Optimization

Using the Global Optimization Toolbox, you can formulate optimization models easily inside the powerful Maple numeric and symbolic system, and then use world-class optimization technology to return the best answer robustly and efficiently.

Grid Computing

With the Maple Grid Computing Toolbox, you can distribute computations across the nodes of a network of workstations, a supercomputer, or the CPUs of amultiprocessor computer. This allows you to handle problems that are not tractable on a single machine because of memory limitations or because it would simply take too long.

BlockImporter™

BlockImporter allows you to import a Simulink® model into Maple and convert it to a set of mathematical equations. It can then be analyzed, optimized, simplified, turned into a MapleSim custom component for inclusion in MapleSim, and exported back to Simulink® using the MapleSim Connector.

"In comparison with others, Maple can do in a couple of hours what other software can take days to compute. The natural math notation allows me to enter the equations as if I were writing them by hand. The fact that I can do symbolic calculations allows me to do optimizations that are virtually impossible with other software. What's more, the results are extremely accurate."

Jean-Louis Ligier, Research and Development Manager, Renault

"It was very simple to work in Maple, even with the complex mathematics involved. We found it quite easy to enter and modify equations, determine whether they had a solution, then go back and make necessary changes. I found Maple's user interface very easy and smooth to work with; it is now invaluable in rapid solution development."

Dr. Frank Allmendinger, R&D, Marquardt GmbH

Powered by Maple

MapleNet™

Bringing the Power of Maple to Your Applications and Web Sites

MapleNet's suite of mathematical services brings the power of Maple to your applications and web sites. With MapleNet, you can add mathematical computations and visualizations to your web and desktop applications, share solutions over the web through interactive Maple documents, and develop rich technical web content.

- **MapleNet provides a standard web services application programming interface (API)**, making the computational power of Maple available no matter what language or infrastructure you use to create your web site, desktop applications, and mobile applications.

- **With MapleNet, you can easily share your Maple documents, calculators, and technical applications.** Your colleagues and students can interact with your content, perform calculations, and visualize results, all from within a standard web browser. Maple provides the easiest interface available for creating web applications that rely on mathematical computations.

- **MapleNet provides the tools you need to put mathematical power behind your web site.** MapleNet supports web content written as Java Server Pages (JSP), Java applets, and Maplet™ applications. With MapleNet, you can design custom web applications that perform live calculations based on user input and display the results using standard mathematical notation and dynamic, interactive plots and animations.
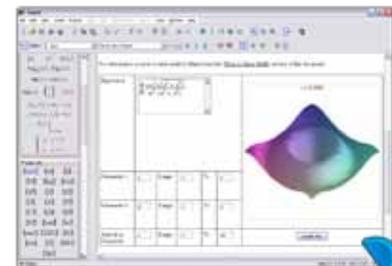
Maple document
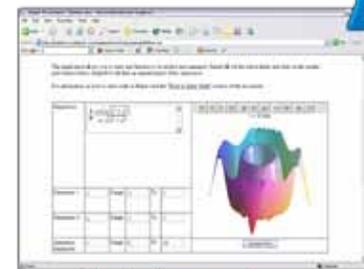
Maple document now available via a web browser

The Unique Advantages of Symbolic Technology

Maplesoft's core symbolic technology has evolved over a period of 30 years and is now considered the most advanced math functionality in the world. Technical professionals around the world have exploited tools in Maple for differential equations, matrix computation, optimization, and statistics, while eliminating round-off error, gaining unlimited precision, and taking advantage of symbolic parameters to better analyze their systems.

MapleSim is based on the same core technology. It is the only comprehensive modeling system built within a natively symbolic framework and, as such, it avoids some of the worst sources of error and computational inefficiencies generated by traditional, numeric-based modeling tools. Symbolic computation is quickly becoming one of the most important and defining technologies of next generation modeling techniques.

With its symbolic approach, MapleSim provides many advantages, including:

- Automatically generated system equations
- Algebraic simplification of model equations without loss of fidelity
- Symbolic reduction of DAEs to index 1
- Elimination of algebraic loops
- High-accuracy stiff solvers through the use of exact, symbolic Jacobians instead of numeric approximations
- Commonly used multibody properties, such as mass matrices, constraint Jacobians, and force functions
- Advanced analysis: sensitivity, optimization, inverse kinematics, inverse dynamics, and more
- Highly sophisticated event detection and handling
- Advanced code generation and optimization

Professional Services

Maplesoft Professional Services and Consulting

Maplesoft has expertise in system-level modeling and simulation, covering a wide range of applications and industries. With the physical modeling language, Modelica, at the core of most of our development projects, we specialize in the modeling, simulation, and optimization of complex multidomain systems such as ground transportation, automotive transmissions, space systems, marine plant, batteries, electric powertrain, and much more.

Model development and simulation services

Utilize the deep knowledge of our modeling team to fill gaps in your own resources when developing system-level models or detailed component libraries, as well as when validating models. The results of this work can be integrated with the rest of your toolchain and design process through automatic code generation, data file transfer, or cosimulation.

Analysis service and tool development

Modeling your system enables you to make design decisions very early in the process. Parametric studies to perform "what if" analysis, Monte-Carlo or sensitivity studies, frequency domain - or any other domain - analyses need to be performed on the system to optimize the overall system performance. Our team helps you leverage the analytical power of Maple to develop customized analytical tools that suit your immediate needs, in an environment that is fully open to modifications as your needs change.

Real-time plant-model code generation

Whether you are working on hardware-, software- or operator-in-the-loop applications, it is critical that your system models run on a real-time platform within the simulation time-step. The symbolic model formulation and optimized code-generation in MapleSim guarantees you the fastest possible execution time for your model. However, with large systems, even the fastest possible time may not be fast enough. When that happens, our team has extensive experience in rigorous model-reduction techniques and code optimization that maximize fidelity within the constraints of working on a real-time platform.

Training

There is no substitute for your engineers spending time with a seasoned expert in the use of any software tool to maximize productivity, competence, and confidence in the tool. We provide standard 3-day courses for MapleSim, Maple, and Modelica that can be customized to suit your specific needs.

Licensing Options

Maplesoft offers a variety of cost effective and flexible licensing options. Ask about a customized solution tailored to your organizations specific requirements.

Options include:

- Single-user licenses
- Multi-user licenses (floating and non-floating)
- Customized licensing programs

We will be happy to work with you to find the best solution to meet the needs of your organization.

Customer Stories

Game Changing Hockey Sticks with Help from MapleSim

Hockey Robotics is a company that has pioneered the concept of robotic testing for the hockey industry. It specializes in hockey stick design, performance, and durability testing using an advanced hockey stick testing robot. Hockey sticks most often break during a slap shot; therefore the company's goal was to produce a robot capable of properly mimicking the professional hockey slap shot. The Hockey Robotics team, with support from industry partnerships, manufactured the SlapShot XT, a dynamic hockey stick robot capable of delivering a slap shot at speeds up to 110 mph. Hockey stick manufacturers are now using the robot to test their designs in a highly repeatable and controlled manner, providing evaluation data never before available.

MapleSim played a critical role in the design and development of the SlapShot XT. It allowed Hockey Robotics to efficiently and accurately simulate the coupled dynamic electrical and mechanical behavior of the equipment. MapleSim enabled the concurrent study of the flexible body deformation and rigid body motion of the machines, which is a very difficult, time-consuming, and error-prone task when done by hand. It also allowed them to quickly prototype the designs and investigate the coupled motion of the mechanisms very easily.

The result was definitive: The robot provides repeatable, unbiased test data on the performance and durability of hockey sticks, a first in the industry.

"MapleSim is the engine driving our development," said Dr. John McPhee, Chief Scientist at Hockey Robotics. "It has been crucial in our development and testing, resulting in tremendous savings in design and prototyping. In addition, MapleSim allows us to perform engineering analysis that was previously too challenging and computationally intensive for our industry to undertake."

From Months to Days With MapleSim and Maple

3 months to **15 days**

Power-Split Hybrid Electric Vehicle
A complex, multi-domain model that covers all aspects of a hybrid electric vehicle, including a mean value internal combustion engine.

3 months to **10 days**

Planetary Rover
A complex multidomain model that simulates planetary rover motion, wheel/soil interaction, energy consumption, and more.

Maple and MapleNet Streamline the Development of Solar Panel Foil Systems

As a technology consultant, Dr. Peter Waegli works with a wide range of companies to bring the latest and most efficient technology to his clients. His firm, Dr. P. Waegli-Research, provides technology-based strategies and solutions to clients.

Dr. Waegli recently advocated the use of Maple in a project related to solar panels. Solar panels are composed of a collection of connected photovoltaic cells, and the type of cell interconnection technology affects the performance of the solar panel. Eppstein Technologies, a subsidiary of EppsteinFOILS, is a developer of innovative foil systems for interconnecting and encapsulating photovoltaic cells. In a recent project with Eppstein Technologies, Dr. Waegli used Maple and MapleNet to help the company streamline the development process of their foil systems.

A simulation model for a module tester, which illuminates the test modules to measure their power conversion performance, was built in Maple. This model simulates the light distribution and intensity for various arrangements and specifications of the LED-sources. These results were then used to optimize LED positions, properties of the LEDs, and the collimation optics and distance of the LED assembly from the measuring plane. Based on the results of this optimization during the modeling phase, the tester light source was built and performed correctly on the very first try. Maple was then used to create simulation models of the modules. With virtual models of both the modules and the test platform, the company was able to optimize their designs early in the process, reducing the number of expensive physical prototypes they need to create and test.

The model and the results were fully described in interactive Maple documents and shared using MapleNet. As a result, every design engineer on the project has access to the information and can run simulations with their own parameters online.

1 month to **5 days**

Biomechanical Walking Robot
A dynamic model of a walking robot which incorporates both kinematic behavior and ground contact interactions.

1 month to **4 days**

Wind Turbine
A full wind turbine model that simulates stabilized power output using controlled wind blades.

Customer Stories

NASA's Jet Propulsion Laboratory begins widespread adoption of Maplesoft technology

NASA's Jet Propulsion Laboratory (JPL) is implementing Maple, MapleSim, and MapleNet in its various projects. Whether creating America's first satellite, Explorer 1, sending the first robotic craft to the moon, or exploring the edges of the solar system, JPL has been at the forefront of pushing the limits of exploration.

Curiosity, JPL's latest space rover, aims to explore Mars to investigate whether the planet could have ever supported microbial life. Other JPL projects include spacecraft missions to comets, asteroids and the edge of the solar system, as well as satellites that monitor the land, oceans, and atmosphere of our own planet.

Maplesoft products are expected to help JPL save time and reduce cost by providing more efficient and smarter methods for mathematical analysis, modeling, and simulation. In addition to using Maple for advanced mathematical analysis, JPL will use MapleSim, Maplesoft's high-performance physical modeling and simulation platform, as a key tool in its engineering workflow.

Jet Propulsion Laboratory

MapleSim Breaks New Ground in Hardware-in-the-Loop Real-Time Simulation for Planetary Rovers

In the space industry, the design, building, and testing of rover prototypes is extremely expensive. System testing typically does not occur until late in the design/testing process, when it is more difficult and time consuming to make changes. In response to this situation, Dr. Amir Khajepour, Canada Research Chair in Mechatronic Vehicle Chair, and his team worked with the Canadian Space Agency (CSA) and Maplesoft to develop a hardware-in-the-loop (HIL) test platform for solar powered planetary rovers.

Their approach allows component testing within a simulation loop before a full rover prototype is available. It essentially creates a virtual testing environment for the component under test, "tricking" it into thinking it is operating within a full prototype. Using MapleSim, the modeling and simulation tool from Maplesoft,

high-fidelity and computationally efficient models were created for this real-time application.

"Due to the multidomain nature of the system (mechanical, electrical and thermal), it was desirable to model all the components within one modeling environment such that critical relationships can be easily discovered. In addition, computational efficiency is crucial in real-time simulations," said Dr. Khajepour. "MapleSim was found to be the ideal environment for this application due to its multidomain abilities, use of symbolic simplification for higher computational efficiency and ease of connectivity to LabVIEW."

Selected Customers:

Cleveland GOLF · RENAULT · Ford · ULYSSE NARDIN · SMTC · Isuzu Advanced Engineering Center, Ltd · Mitsubishi UFJ Securities International plc · TOYOTA · Jet Propulsion Laboratory · MDA · MOOG · B&R · AMTC CTFA Aerospace Manufacturing Technology Centre / Centre des technologies de fabrication en aérospatiale · Canadian Space Agency

Maplesoft Resources

Professional Services

Maplesoft's Professional Services can help you implement your modeling and simulation strategy in a timely and cost effective way. Our highly experienced application specialists, mathematicians, and computing experts are the ideal complement to your team.

Visit www.maplesoft.com/products/proservices

Training

Maplesoft offers a comprehensive set of complementary training materials. From training videos to recorded training seminars to downloadable documentation, you have many options to get up to speed with Maplesoft products. In addition, whether you are an expert or someone who is evaluating our products for the first time, Maplesoft can provide a custom training session that is right for you.

Visit www.maplesoft.com/support/training

MaplePrimes

MaplePrimes is a web community dedicated to sharing experiences, techniques, and opinions about Maple, MapleSim, and related products, as well as general interest topics in mathematics and engineering. MaplePrimes provides a platform for enthusiasts to present their thoughts and for inquiring minds to get answers.

Visit www.mapleprimes.com

Social Networking Communities

In addition to MaplePrimes, other online communities for Maplesoft enthusiasts are available through the social networking sites Facebook® and LinkedIn®. Join these groups to meet like-minded users, share interesting information, and learn more about Maplesoft and its products. You can also visit the Maplesoft channel on YouTube® to watch tutorials and other videos on mathematics, engineering, and related topics, or you can follow Maplesoft on Twitter™.

MapleSim Model Gallery

The MapleSim Model Gallery contains a number of real-world application examples created using MapleSim. See for yourself the breadth and depth of MapleSim applications.

Visit www.maplesoft.com/products/maplesim/gallery

Application Center

The Application Center features over 2,000 applications and tutorials contributed by the Maplesoft user community. This growing collection of applications shows how Maplesoft solutions are applied to critical technical projects, in interesting real-world problems, and in education.

Visit www.maplesoft.com/applications

MapleCloud™

You can instantly access content created by Maple users worldwide using the MapleCloud Document Exchange. This dynamic collection of Maple documents is available from within Maple itself and can be loaded into your Maple session at the click of a button.
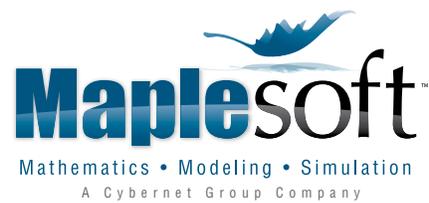
Maplesoft Webinars

Maplesoft's monthly webinars provide an excellent opportunity to learn about interesting applications, new techniques, and products. Hosted live by senior Maplesoft representatives, these one-hour interactive sessions also offer the opportunity to ask questions and interact with the presenter.

Visit www.maplesoft.com/company/webinars

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