The Mechanics of Composites Collection

Material Minds Software

A Product of Materials Sciences Corporation

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The Materials Minds Philosophy

Engineers are smart people that want the building blocks and tools to get a job done. Their tasks require creativity. Therefore, it is impossible to anticipate all of their needs in a rigid point-and-click environment. The engineering workflow is more like a language. The engineer needs to be able to manipulate nouns and verbs to get the precise results needed. Our goal is to provide a rich language for performing analyses and design using advanced composite materials. Imagine a building block approach in which the output from one operation feeds naturally into the next operation. Integrating user extensions should be natural and not require specialized programming skills.

There is a rich history in elasticity of heterogeneous, anisotropic materials. Take full advantage of that history. There is no need to default to an approximate numerical method when an analytic solution exists. Use the computer to handle complex solutions and make it practical to have the classic solutions available for everyday use. Don't make any unnecessary approximations. Keep the solutions as general as possible.

Take advantage of the best possible programming and mathematical environment. Our codes are built using the world-class Mathematica system by Wolfram Research. Wolfram has already made sophisticated numerical algorithms, graphics, and symbolic manipulation available.

Build a system that continually grows. Build a community of users. Make the tools that the experts at Materials Sciences Corporation use available to everyone.

For more information, and example output notebooks, see http://www.materials-sciences.com/matlMinds/. If you have questions, or are ready to start using Material Minds, please contact us at software@materials-sciences.com

Topic Areas Covered in Current Release

Mechanics of Composites

Micromechanics

A full set of effective property calculations for particulate reinforced, and fiber reinforced composites. Phase average stress and strain output. Consistent handling of thermal stresses.

Lamination Theory

Stiffness arrays with full generality. Layer-by-layer stress and strain including thermal effects. Effective transverse shear stiffness, and shear stress distribution. Carpet plots of elastic properties. Failure envelopes.

2D Weaves

General methodology for calculating effective properties of any 2D weave pattern. Integrations account for yarn undulation pattern. Phase average stress output. Proper handling of thermal stress.

Elasticity Solutions

Elasticity Solution for Circular Hole

A rich implementation of the Lekhnitskii anisotropic elasticity solution for a hole in an infinite plate. Stress can be evaluated at any point. Far-field loads, assumed bolt loading, or user defined edge pressure distribution. Moment distribution around hole due to far-field bending.

Multilayer Elasticity

Elasticity solution for anisotropic layers. Assumes a trigonometric distribution of displacements in the inplane directions. Governing equations solved in thickness direction.

Multilayer Curved Beam

Elasticity solution for a multilayer beam with orthotropic layers. Capable of handling net moment, radial, and tangential loads. Thermal stress components included.

Free-Edge Stress

Stress-function based series solution for the free-edge stresses of a laminate.

Free-Edge Fracture

Compliance change method for determining total strain-energy-release-rate for a laminate with an edge delamination.

Strain to Displacement
Use Mathematica’s symbolic integration capability to determine displacement distribution from a compatible strain distribution.

Section Properties

Exact Section Properties
Calculated all of the standard 2D section properties such as area and moments of inertia for a section defined as a collection of curves. Uses Mathematica’s exact integration technology. Output can be symbolic.

Laminated Section Properties
Simple modulus-weighted section property calculator that assumes each laminated element of a collection as a rectangular section with arbitrary orientation and position relative to an origin.

Anisotropic Plates

Rectangular Plates
Numerical solution for thick (shear-deformable) rectangular plates with any combination of classical edge boundary conditions. Can compute deflection with pressure loading (including nonuniform distributions of pressure), buckling loads, and vibration frequency. Uses a Legendre polynomial based series solution.

Large Deflection
Deflection of a simply supported rectangular plate with first order large deflection terms. Includes the ability to compare small deflection, large deflection, and membrane assumptions. Shear deformable plate theory.

Annulus on Elastic Foundation
Exact solution for annular plate on an elastic foundation. Useful for determining clamp-up loads, and other local loads in sandwich construction. Also includes a non-axisymmetric loading version.

Statistics

B-Basis
Basic MIL-17 calculation method for determining the B-Basis of a single set of data.

Random Variables
General methodology allows any input to any model to be declared as a random variable. Effective of random variable can be propagated through the model using approximate closed-form methods, or Monte-Carlo simulation. Distributions for output variables can be plotted, or automatically summarized using assumed distributions.

Joints

Bolted Joints
Collection includes the “Splice” package that performs a bolted joint analysis for joint assemblies that may have several layers of plates, and several bolts. The bolt is treated as a beam-on-an-elastic-foundation. The overall joint load distribution is computed based on a calculation of the bolt stiffness at each penetration. Contact and heel-toe action is treated using a nonlinear solution algorithm.

Why Mathematica ?

The Material Minds system is built on *Mathematica* by Wolfram Research. User's are required to have a license for *Mathematica* 5 or greater in order to run any of the Material Minds modules.

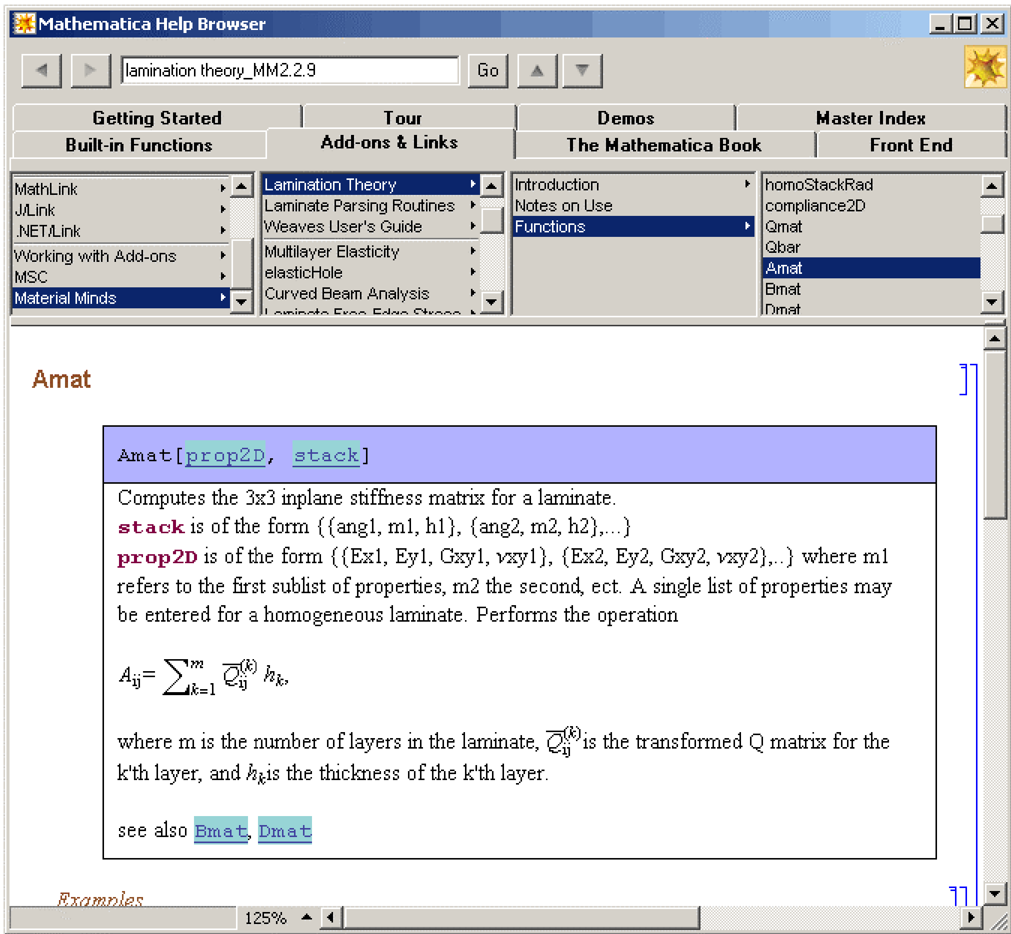
Mathematica is a high-end scientific computing environment. One may ask why Material Minds requires this extra expense instead of a stand-alone application. To put it simply, there is no way a specialty engineering software package could afford to reproduce a fraction of the capabilities of *Mathematica* in terms of front-end presentation, numerical capabilities, cross-platform capabilities, and graphics. The ability to do symbolic computation is added plus. Building on *Mathematica* allows MSC to focus on the mechanics of composite materials and structures.

Material Minds takes full advantage of the *Mathematica* Help Browser (screen shot below). The Help Browser is an interactive, hierarchical database of all the function names, argument lists, examples, and other help related information. Examples can be altered and executed on the spot to get quick results.

There are several modes available for working with the Material Minds code. The easiest and fastest is to simply modify the Help Browser presentation. The Browser can be treated as an interactive, living handbook. However, in this mode, results cannot be stored for latter reference. The next level of use is to modify existing notebooks. The Help Browser is built on standard *Mathematica* notebooks. These notebooks are given to the user for modification. The altered notebooks can be stored and printed. Advanced users will begin to construct notebooks from scratch. This requires some knowledge of *Mathematica* syntax and notebook interaction. Finally, it is possible link *Mathematica* to other codes and applications so that the Material Minds functions are available to other applications.

In the real world of engineering, one frequently needs to perform an operation on large sets of data. An example would be the output of a general-purpose finite element code. *Mathematica* is well suited for imported large tables of numbers and perform operations on the entire set.

Screen Shot of Help Browser Page



Purchasing the Mechanics of Composites Collection

Pricing

A single user license for the complete collection is $2000. The price includes:
Download or CD of all packages, notebooks, and help files

- Printed version of help files
- Email support for one year
- All updates and expansions for one year

After one year, continued updates and support can be purchased for $500/year.
Mathematica can also be bundled with the collection. Contact MSC for pricing details for the Mathematica bundle and site licenses.

Price with Training

Training at the user facility is $4,000 per day, plus travel expenses for one instructor plus $2000 per student. This price includes a full standard software license for each student. There is no additional charge for students that have previously purchased a license. The instructors are senior MSC engineers will applications experience.
The Mathematica licenses can be bundled with the training. Contact MSC for pricing details.

Introductory License

If the full package is too big a step, you can explore the principles of Materials Minds by using just the lamination theory package. The Introductory license provides the lamination theory code, along with associated help files. The cost is $400 per user license. The license includes 60 days of email support. A Mathematica license is also required.

Source Code

The packages (source code) for the collection will be encrypted. Notebooks (example files and help) are completely open. This means you can use all of the packages, but you will not be able to view the source. A license for the unencrypted source can be purchased for $6000. This license will allow you modify the packages. A modified package can be used by anyone at a user site that has an existing standard license.

For Free

The Materials Minds software powers our web-based calculators at http://calc.materials-sciences.com. These pages are provided as a free service by Materials Sciences Corporation.

For More Information

Please write us at software@materials-sciences.com. We can customize a pricing proposal for your situation. MSC can also write custom packages and notebooks to fit particular applications and user needs.

Who are we?

Material Minds is a brand name for commercial software developed by Materials Sciences Corporation (MSC). MSC is a leader in engineering using composite materials, with an emphasis on computer simulation and analyses. It is a goal of MSC to make portions of our valuable proprietary software available to the public. The name Material Minds is used to distinguish the commercial side of our software technology, and the special attention required to support these products.