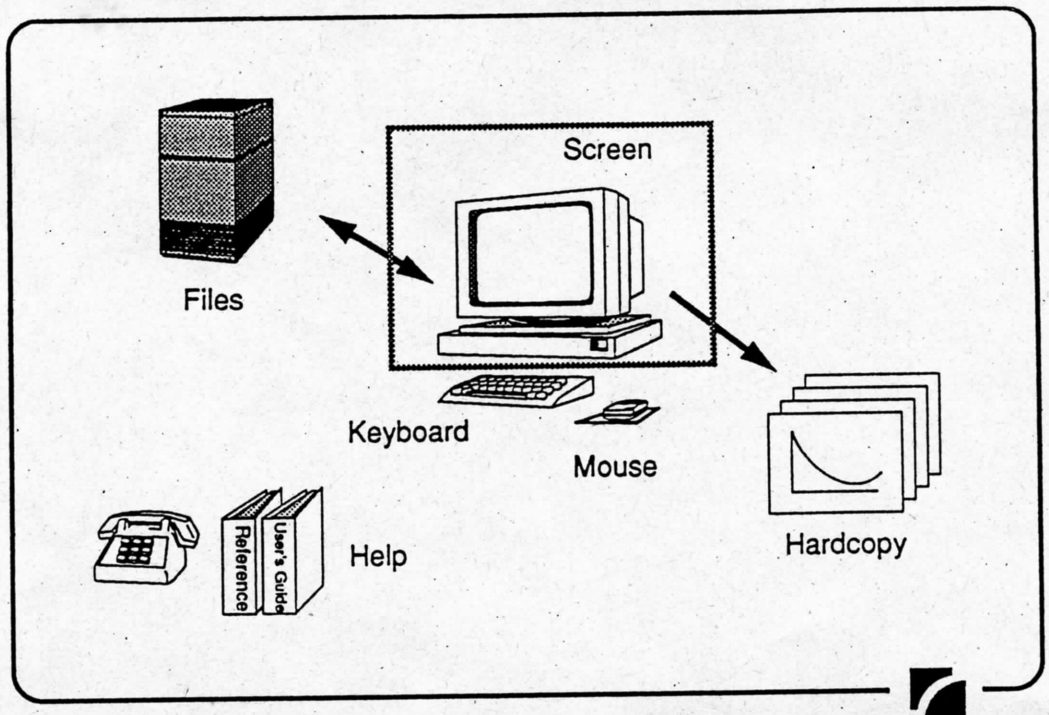
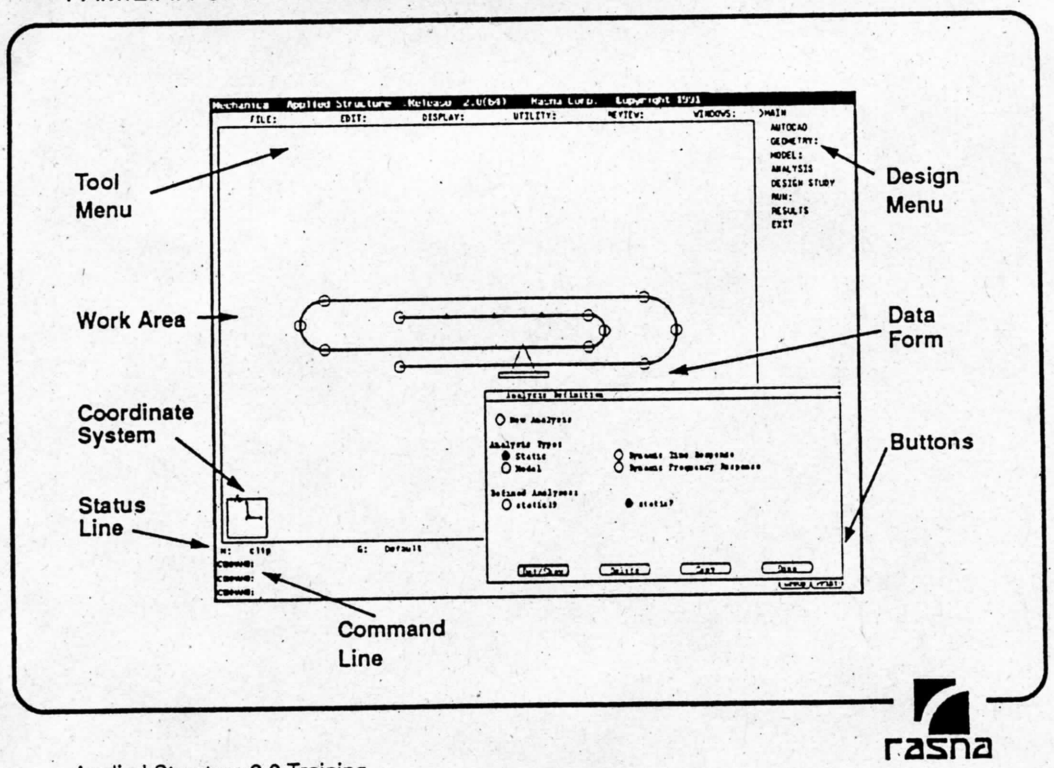
THE SCREEN IS THE MAJOR OUTPUT DEVICE



FAMILIAR CAD-LIKE SCREEN LAYOUT



Applied Structure® Release 2.0 Specifications

Applied Structure is a member of the Mechanica® family of design optimization tools. Providing engineers with analysis, design sensitivity and optimization capabilities, Applied Structure provides a powerful platform in an easy-to-use format for automating mechanical design.

User Interface

Interactive Graphics

- Used in all phases of model creation, analysis and results display.
- Automatic model error detection.
- Multiple level undo/redo.
- Menu-driven with dialog boxes and data forms.
- Unlimited tiled or overlapping windows.
- Entity grouping facility.
- Wireframe flat fill or solid-shaded displays.
- Dynamic viewing options for real time model rotation, pan or zoom.
- Entity visibility control.
- User profile defaults.
- Context-sensitive on-line help.

Modeling

Geometry Definition

- Points, curves (arc, circle, ellipse, fillet, helix, line, polyline, rectangle, spline), surfaces (cone, cylinder, extrude, lofted, trimmed planar, revolved, swept, 3 and 4-sided Coon's patch).
- Construction lines and planes

Local Coordinate Systems

Cartesian, spherical and cylindrical.

Analysis Modeling

- Geometric Elements include masses, springs (point to point and point to ground), beams (straight and curved), shells (triangular and quadrilateral), 3D solids (tetrahedron, pentahedron and hexahedron), continuum elements for plane stress, plane strain or axisymmetric (triangular and quadrilateral), and 2D shell elements (plane strain or axisymmetric).
- Automated element creation method includes revolve, extrude and AutoGEM™ (automatic surface meshing).
- Links provide the capability to automatically generate constraint relationships between discontinuous Geometric Element Model™ (GEM) entities. Links can include shell to shell edges, beam to shell edges, shell edges to 3D solid faces, solid to solid faces, edge to edge for all 2D elements.
- Isotropic material properties.
- Beam endpoint offsets.
- External libraries available for material, beam section and spring stiffness properties.
- Loads can be applied directly to geometry or to Geometric Element Model. Loads can be specified in global or local coordinate system. Types of loads include: force, pressure, gravity, centrifugal, thermal.
- Constraints can be applied directly to geometry or to GEM. Constraints can be specified in global or local coordinate system. Constraints can be free, fixed or enforced displacement.
- Response quantities may be globally or locally tracked.

Geometric Associativity

Fully associative database ties elements to geometry; a change in one automatically changes the other.

Design Variables

Features identified by the user that may change in order to optimize design performance. Design variables can include translation, rotation and scaling of points, curves or surfaces; curve midpoint position, curve radius, arc angle, beam properties and orientation, spring stiffness and orientation, shell thickness or material properties.

Model Editing

Full capabilities are provided.

Analysis

Types

Linear static, modal, dynamic time response and dynamic frequency response.

Quality Control

- Automatic analysis convergence based on local and global measures of specified error norms.
- Local, directionally independent adaptive process.

- User may optionally specify global and local upper and lower bounds on element polynomial levels; and locally specified sacrificial elements.
- Solution convergence may be defined by user-specified quantities including strain energy, displacement, frequency or stress.

Design Studies

Design Sensitivity Analysis

- *Local*: user can change one or more design variables a small amount and compute the change in all measures with respect to the design variable.
- *Global:* user can sweep one or more design variables over a range of values to find the optimal performance for each response quantity over that range.
- *Offset:* user can specify a new value for any number of design variables and complete analysis results are provided for the proposed design change.

Optimization

- Goals: minimize, maximize a goal given to the optimizer. May be mass, cost, stress, displacement, rotation, frequency.
- Identify design variables.
- Limits: one or more optimization limits may be placed on mass, costs, stress, displacement, rotation or frequency.
- Multiple analysis types.
- Multiple load cases.

Results

Display Quantities

Displacement, stress, strain, strain energy, force, convergence data, response quantities.

Display Locations

Entire model, by group, over surface, along curve, single point, beam cross section (multiple locations).

Display Types

Fringe, contour, model animation, XY graph, vector results.

Interfaces

- Integrated CAD systems include AutoCAD, CADKEY.
- CAD interfaces include DXF and IGES.
- Hard copy includes PostScript and HPGL, and HP Paint Jet (PC only).

System Requirements

Workstations (UNIX)

Models:	Sun-4/Sparcstation; SGI 4D/20, 4D/25, 4D/35; DECstation 2100, 3100, 5000; IBM RS6000
Software:	SunOS 4.1 or higher; IRIX 3.3.1 or higher; ULTRIX 4.0 or higher; AIX 3.1.5 or higher
Windows:	X-windows; SunView; 4sight; DECwindows
Memory:	8 MB minimum, 16 MB recommended
Disk Space:	50 MB UNIX swap partition; 120 MB free disk space (recommended)
Network:	NFS
Devices:	2 or 3-button mouse, color monitor, cartridge tape drive (on network)

Personal Computers (DOS)

Models:	386 or 486 100% IBM compatible PC
Coprocessor:	80387 or 80487
Software:	DOS 4.01 or higher
Memory:	8 MB minimum, 16 MB recommended
Disk Space:	120 MB free disk space (recommended)
Devices:	2 or 3-button mouse, color monitor, 3 1/2" or 5 1/4" high density floppy drive, one parallel port, graphics card (VGA, VMI Cobra Plus, Matrox PG 1281-CV, VMI X Series)

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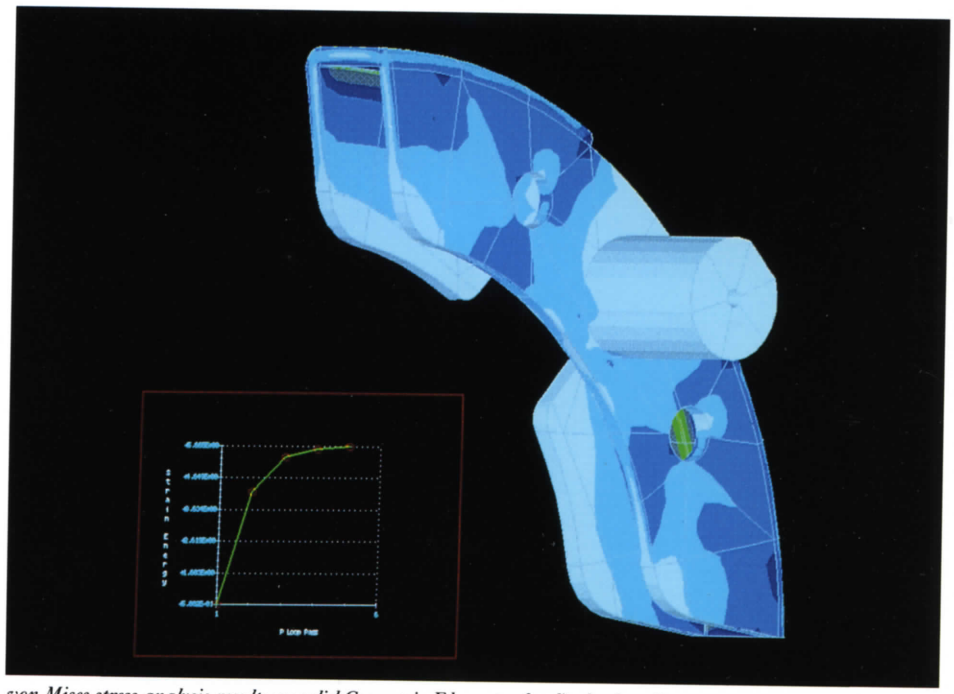
Easy, Fast, Accurate Structural Optimization with Mechanica



von Mises stress analysis results on solid Geometric Elements of a disc brake caliper. XY Plot displays solution convergence.

Mechanica® Design Optimization Tools.

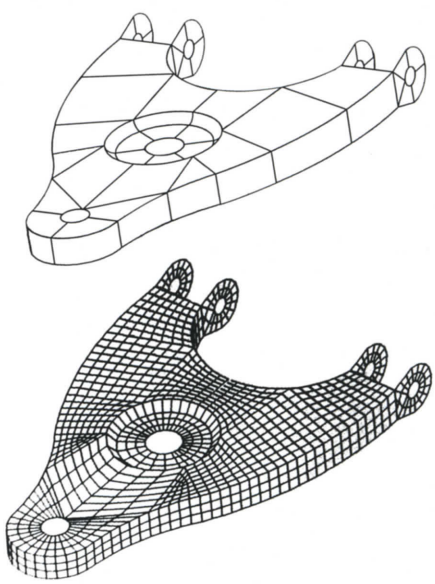
Mechanica tools provide an innovative approach to the way you do your work. These software tools offer a CAD-like interface, making them fast to learn and easy to use. In fact, you'll be optimizing your own designs in a fraction of the time it would take using a conventional tool.

When we say easy-to-use, we mean more than our pull down menus, undo/redo command, flexible windowing and simple entry data forms. We mean advanced technology that provides an intuitive format, allowing you to work the way you think.

Applied Structure™

Applied Structure incorporates analysis techniques to make design engineering easier and faster. This tool doesn't just validate (or invalidate) your design, it guides you through the design process to find the best possible design.

Applied Structure's functionality is completely automated. No more complex finite element meshing. Even specific element types are chosen automatically. And larger, more robust elements based on simple geometric shapes are all that is required, making modeling a snap.



The Geometric Element Model™ (top) illustrates how easy modeling is using Geometric Elements, as compared to complex conventional meshing.

EASY-TO-USE ANALYSIS

A 2D and 3D structural analysis and true shape optimization tool, Applied Structure provides static, dynamic and modal analyses. The advanced technology incorporated in this tool's Geometric Element Analysis™ (GEA), enables an engineer to quickly model, evaluate and optimize a part design.

GEA takes the cumbersome manual and technical input out of analysis. Work you performed in months using a conventional analysis tool, you'll perform in days using Applied Structure. This tool's adaptive analysis means that you only create one model to perform any number of analyses. The meshing, analyzing, re-meshing, re-analyzing, re-meshing (etc.) process is gone.

And you get high quality graphical results, including stress and deformation plots (both contours and fringes), convergence plots, XY plots, and stress vector plots, among others.

CONFIDENCE

But most importantly, you'll have real confidence in your results. How? Because you choose the level of analysis accuracy you require. Ask Applied Structure for the answer and you're provided with detailed and graphical descriptions of how your analysis converged. No more re-running several analyses and manually plotting the results.

DESIGN INSIGHT

Design sensitivity is an important feature enabling you to get insight into your design in order to optimize it. With Applied Structure, you can evaluate several design options with just one model. If you want to know how hole radius or location affects stress in your part, you simply ask Applied Structure for a plot of the results.

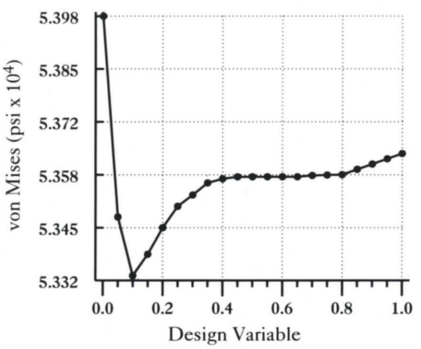
Applied Structure provides three types of design sensitivity studies: local, global and offset.

Local sensitivity enables you to vary a parameter over a narrow range to test the response in design performance to small changes (such as manufacturing tolerances).

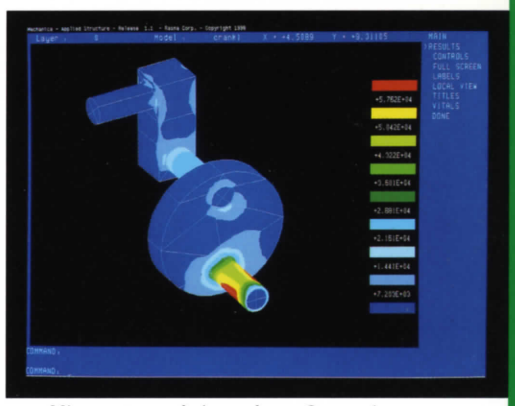
Global sensitivity allows you to specify a variable such as hole location and sweep it over a wide range of design space to study its impact on stress or resonant frequency.

Offset sensitivity provides the capability to specify an offset value for any number of design variables and Applied Structure supplies complete analysis results for the proposed design change.

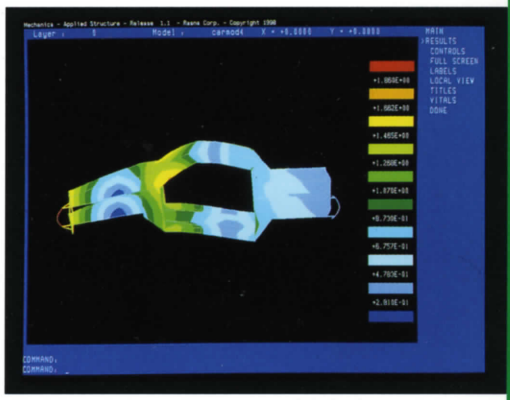
Amazingly, you can perform any or all of these analyses (or several of any one of them) without ever having to re-mesh the model.



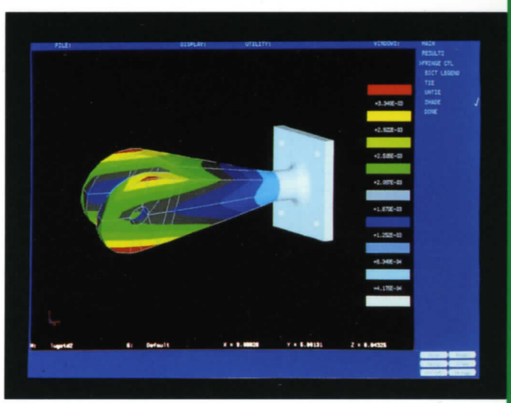
Design Sensitivity runs through several design options (internally, on one model) to search for the configuration that provides the lowest stress. A plot of the results indicates the solution.



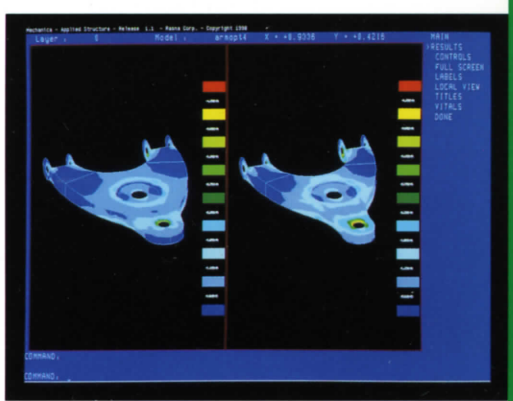
von Mises stress analysis results on Geometric Element Model™ of machinery crank.



Modal analysis results on automobile body showing seventh mode shape.



Deformation results due to loads on solid model of lug.



von Mises stress results for original and optimized model of automotive suspension lower control arm.

TRUE DESIGN OPTIMIZATION

This is what you've really been waiting for. True shape optimization. No other tool has it.

Let's say your objective function is to minimize weight and maximize fundamental frequency of your part, but you have to stay within stress limits. You know you can change the thickness, width, flange depth or hole radius (or all four design variables). All you have to do is provide that information to Applied Structure, pick go, and in no time this tool calculates the optimized design for you.

Applied Structure won't exceed your stress limits and the goal plots will show you how much weight you've removed. It will also show you the new optimized shape of your part which can then be sent back to your CAD package. No re-drawing. It's that easy.

WHAT'S IN IT FOR YOU?

The best design possible. Faster than you ever imagined. Applied Structure will increase your productivity, eliminate the cost of wasted prototype iterations and reduce the worry of part failure in the field.

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