TRUSS 5.0

TRUSS ANALYSIS AND VISUALIZATION

Programed by
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1- **INTRODUCTION**

Truss Analysis and Visualization is a program for the force analysis of planar trusses and the visualizations of the results. System requirements to run this application: 32Bit Color QuickDraw installed, math co-processor (if using the FPU version).

Some of the features implemented cover:

* Create a new truss design,
* Alter the geometry of an existing truss design interactively through moving the joint locations or by the addition/removal of truss members, truss supports or truss joints,
* Apply loads on a truss,
* Produce free body diagrams of the entire truss or for selected pins,
* Produce a color (pattern) graphical display of the load distribution in the individual members with the color (and pattern) of the members denoting tension or compression showing the relative magnitude of the load,
* Implement Method of Sections and Method of Joints interactively,
* Create QuickTime movies of a car traveling over the truss.

A sample truss design is shown below in Fig. 1a and 1b as it would appear on the screen after performing the force analysis (in color mode or pattern mode).
The advantage of using the pattern mode is if the application was run on a monochrome monitor (SE/30 for example). Remember that this application requires the presence of an FPU and Color QuickDraw even if the system does not support color.
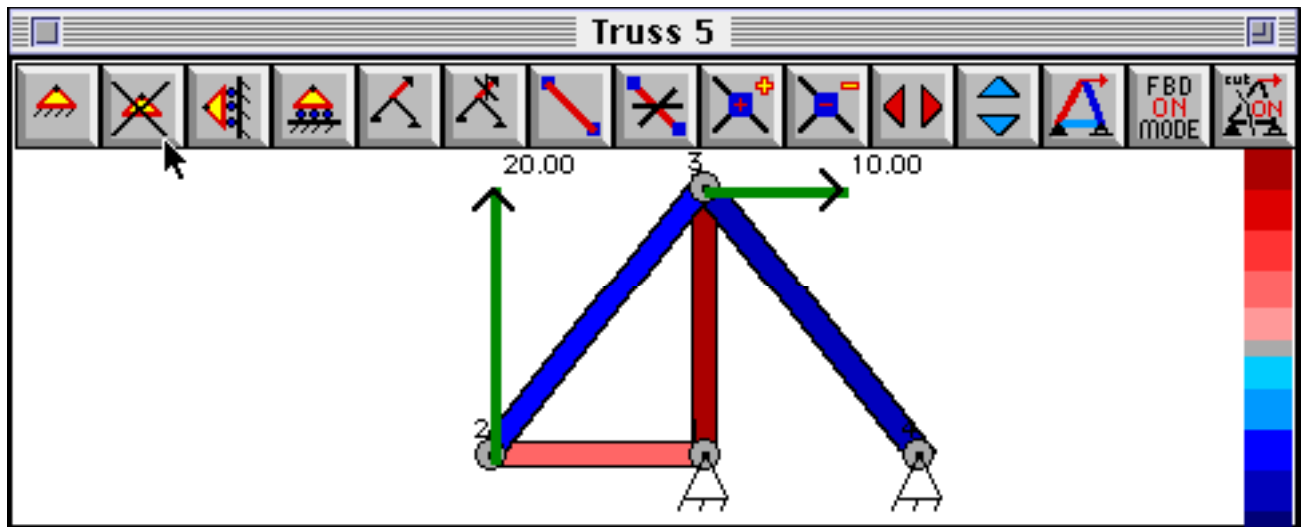
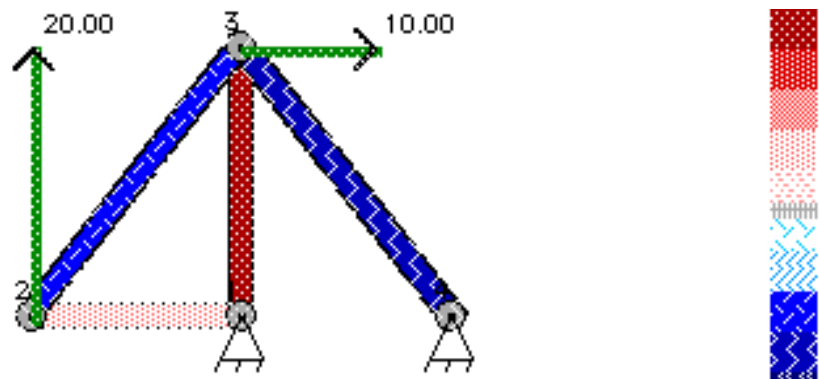**Fig. 1a** Screen view of TRUSS 5 program in color mode.

Fig. 1b Screen view of TRUSS 5 program in color pattern mode.

The right column has the color (pattern) scale for the members following the force analysis: Red colors indicate tension, and Blue colors indicate compression. Gray indicates negligible or zero loads (less than 1% of the maximum member force). The upper column has menu short cuts which can be called by clicking in the appropriate icon after selecting the receiving node or member (connecting nodes).

2- USAGE OF TRUSS ANALYSIS:

To initialize the program double click on the application named TRUSS.

2.1 Creating a truss

This task is very simple:

1. Choose "Create Truss " from "Edit" Menu. This will produce a triangle on the screen which can be moved and altered by dragging the nodes.
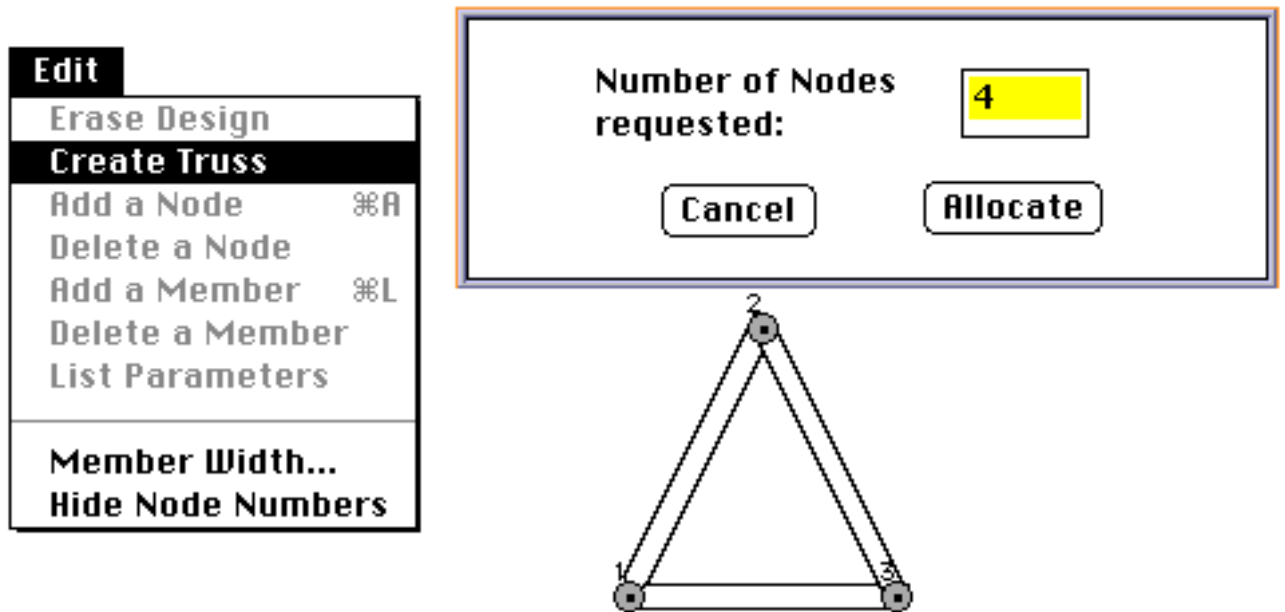

Fig. **2**. Creating a TRUSS .

Note that you have to provide the maximum number of joints that you intend to use in order to efficiently allocate memory to the operation. If you are not sure how many nodes you will need just enter a large enough number. This number does not have to be exact.

2. Select any two nodes by clicking on them, or click on the member, to highlight the member's connecting nodes.
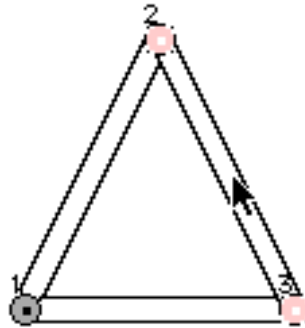
Fig. 3. Selecting a member by selecting its nodes.

3. Choose "Add a Node " from "Edit " Menu. This will add a node and connect it to the two selected nodes.
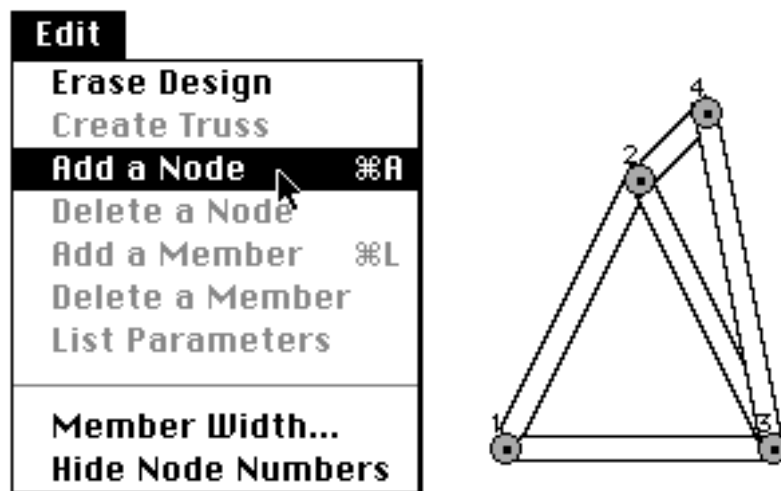

Fig. 4. The node added is selected automatically.

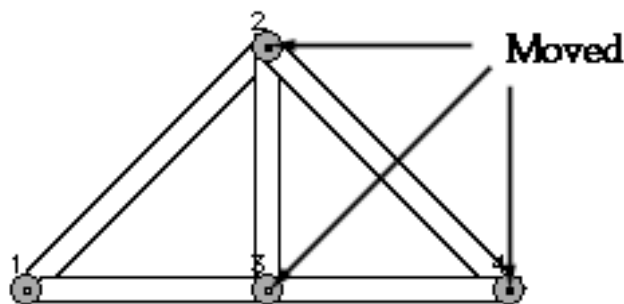**4.** The newly created node can then be moved by dragging it with the mouse button down to the desired location.

Fig. 5. Moving the nodes to obtain the desired structure.

5. Subsequent addition of new members and joints is accomplished by repeating steps 3 and 4.

6. A support can be added at any selected node by clicking it. Make sure that it is the only node selected. You can click outside the truss to de-select all nodes and then click on the desired node.
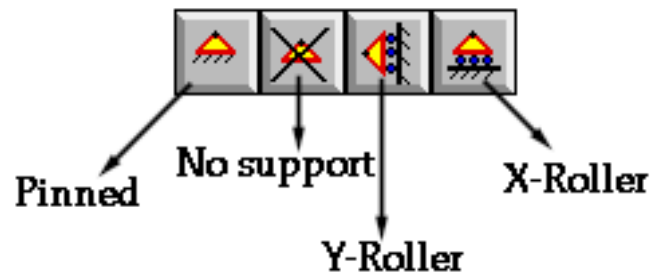

Fig. 6. Support buttons

Click on one of the four types of supports shown in the shortcut strip of **Fig. 1** (pinned, no support, vertical roller, and horizontal roller).

7. Applying a nodal force is accomplished by first clicking on the appropriate node followed by a click on the force option in the shortcut strip (apply/remove load).
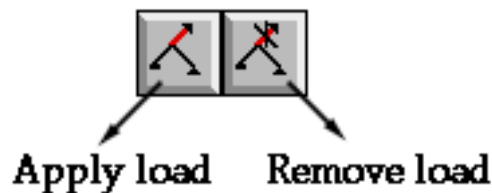

Fig. 7. Loading/unloading a truss

This will bring up a dialog box to the screen prompting the user for the force magnitude and the force direction (in degrees and measured from a right-oriented horizontal line). Type the desired numbers and hit OK when done. Note that a positive force points away from the node, while a negative one will point towards the node.

Fig. 8.

Loading/unloading the truss.
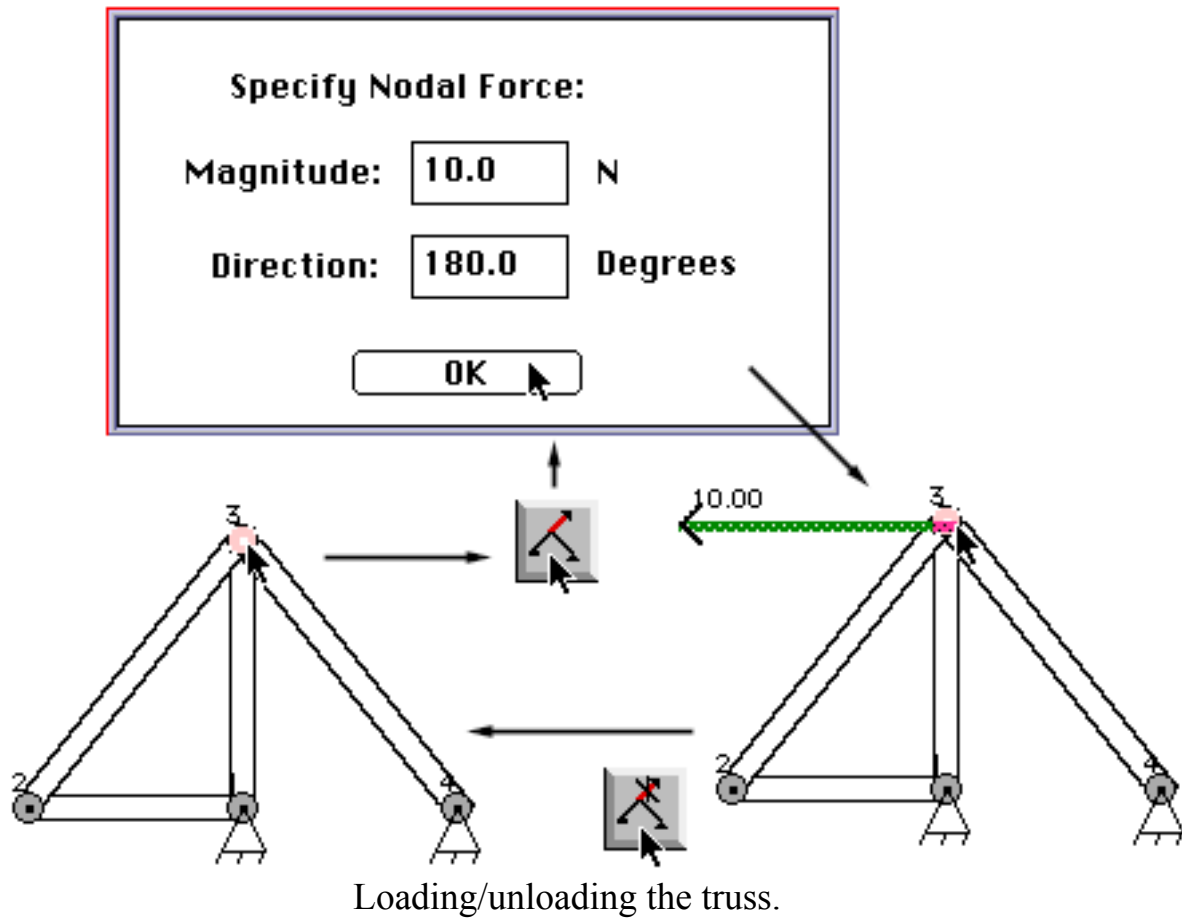
2.2 Alteration of the truss loading

Note that several of these options have shortcut buttons located at the top of the main window:

1. Any node can be moved by first clicking on the node and dragging it to a new location.

2. Any member may be removed by first clicking on the nodes of that member (or clicking on the member) and selecting "Delete a Link " option in the "Edit " menu.

3. A member may be added by first clicking on two nodes where a new member is desired followed by selecting "Add a Link" option from the "Edit" menu.

4. Any force, or support, can be removed by first clicking on the node on which the force, or support, is at followed by a click on the remove force (support) shortcut button shown as a crossed arrow (crossed support).

5. The grid can be of help while creating or altering the truss and the "Align Truss " option in the "Grid" menu will correct any minor misalignments in the links.
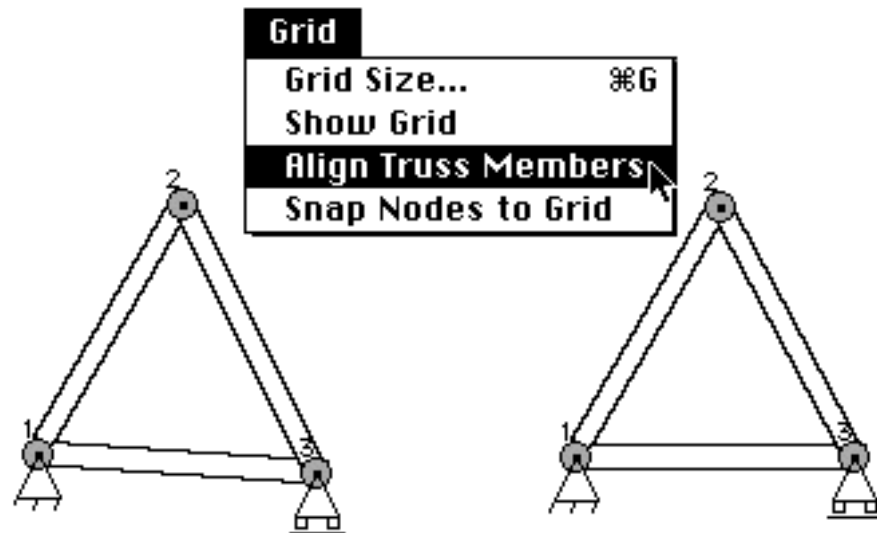
Fig. 9. Aligning the truss in case of minor misalignments.

6. The "Snap Nodes to Grid" option will cause nodes that are fairly close to the grid point to align with it. This is very helpful when designing a bridge truss where most of the members are at uniform distances from each other.
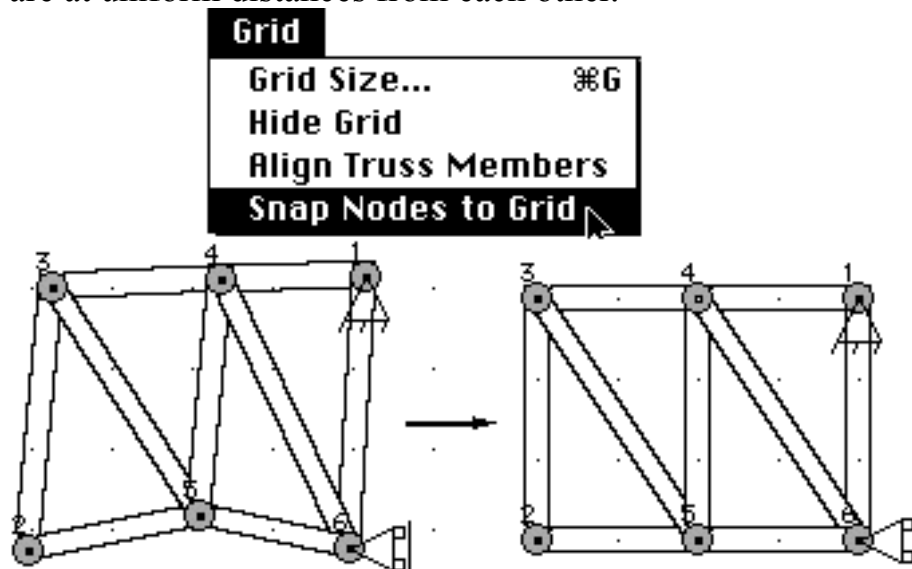
Fig. 10. Snapping the truss to the grid.

7. Dragging a node too close to a member will add the node to that member creating two connected members. Also, moving a node close to another node will make them one node.

8. The entire truss design can be removed by choosing "Erase Design" from the "Edit" menu.

2.3 Analyzing a Truss

Once the desired truss has been created, the analysis step follows with several options:

1. Static Truss Solution: Choose "Solve Truss" Option. This will cause the truss members to be drawn in different intensities of **RED**(*tension*) and **BLUE** (*compression)* so that the forces in the members can be viewed relative to the color scale on the right of the screen.
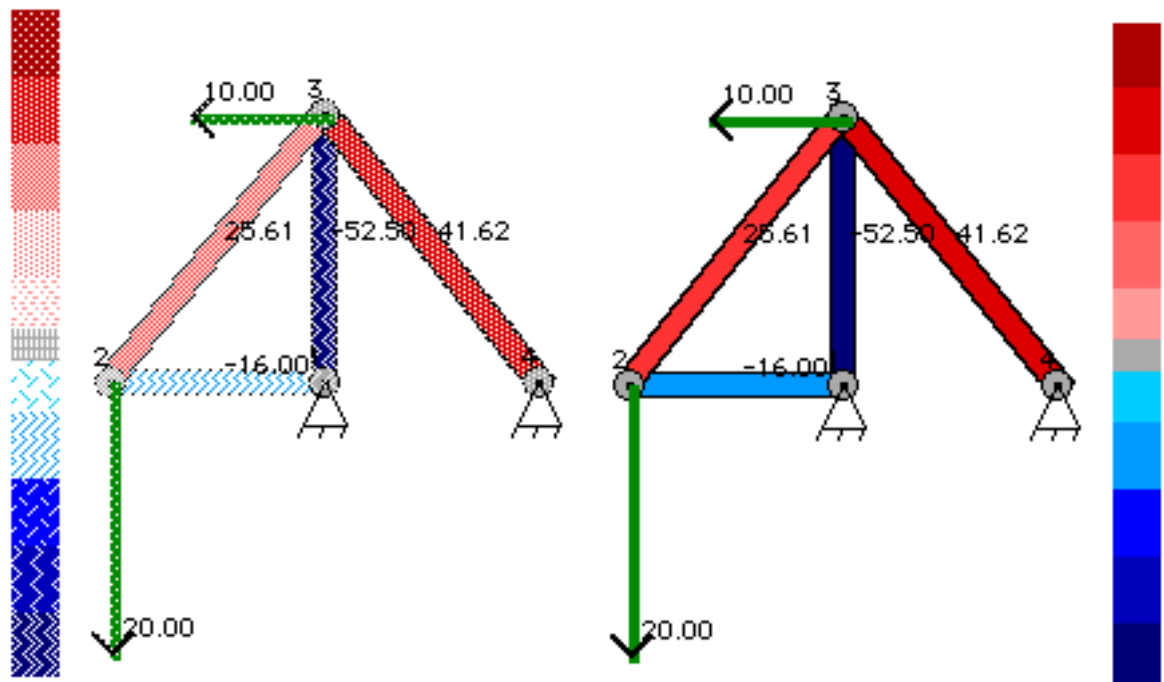

Fig. 11. The truss after analysis, each member is drawn with the color and pattern that indicates its force value.

2. A free body diagram of the whole truss can be viewed by selecting "FBD Truss" option. This will produce a wire frame truss and replace the supports with the appropriate reaction forces drawn in intensities of red with a green arrow tip showing the direction of the reaction force.
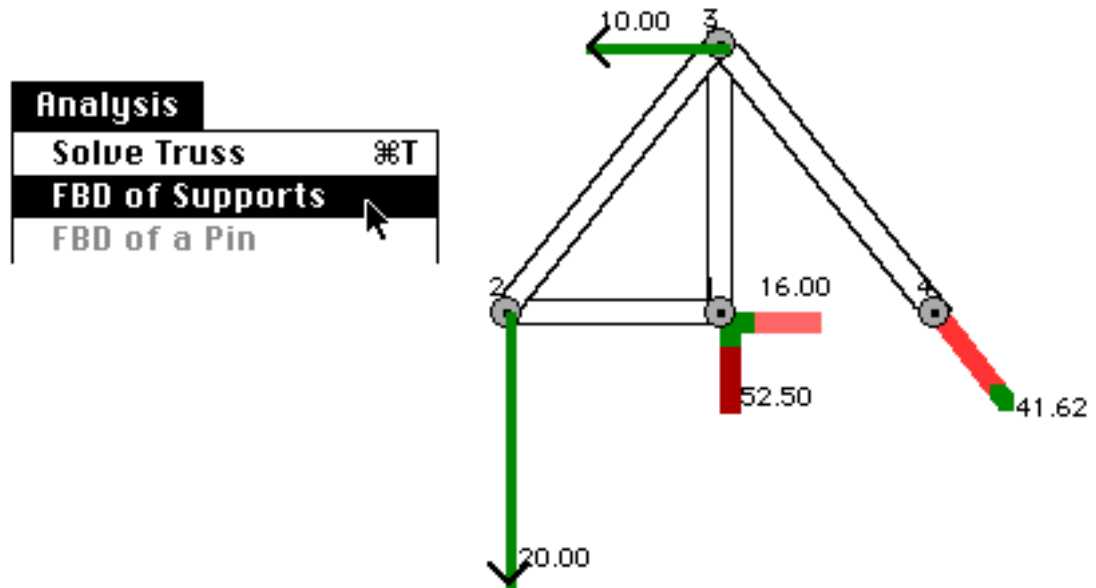
Fig. 12. Free body diagram of the truss showing ground forces at the supports.

3. A free body diagram of a pin starts by selecting a node and choosing "FBD of a Pin". Colored arrows with a green tip will simulate the member forces exerted at the selected node.
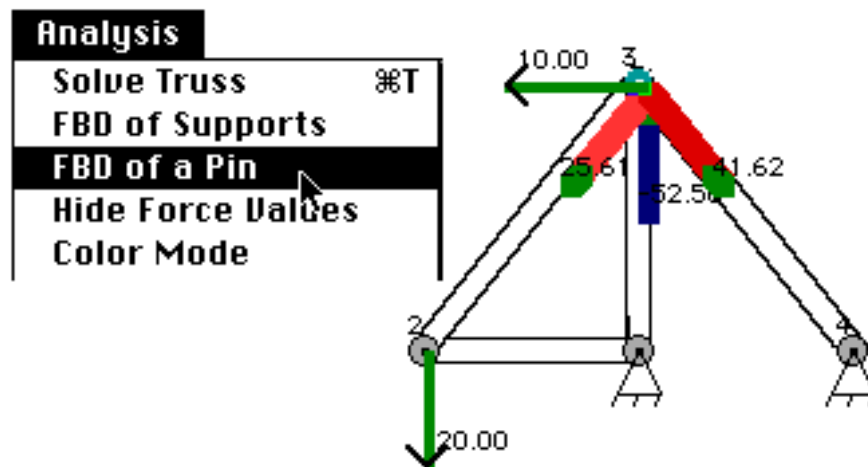

Fig. 13. The free body diagram of a selected node.

Force values can be called to appear on the screen or disappear by choosing either "Show Force Values" or "Hide Force Values".

4. Member forces can be printed in a separate window if "Force List" was chosen, a window will appear having all the member forces and ground reaction forces listed on it.

Window
Truss
Force List
Console

Force List

Truss member loads:	Reaction forces:
F[1][2]=-16.495	RFx[1]=-16.49
F[1][3]=-52.125	RFy[1]=52.12
F[2][3]=25.925	RFx[4]=26.49
F[3][4]=41.641	RFy[4]=-32.12
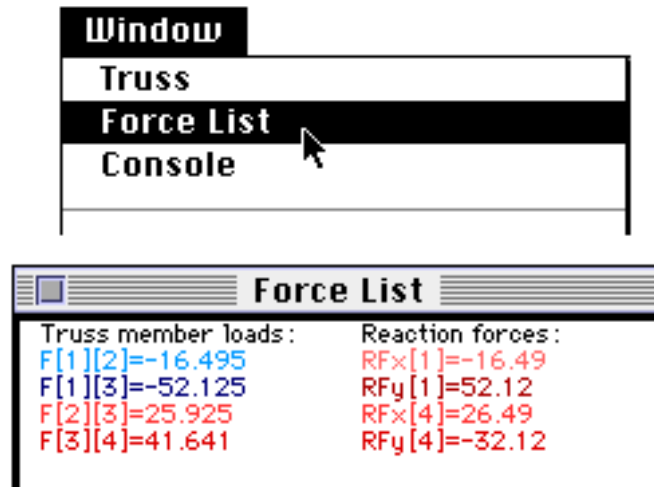
Fig. 14. Another way of obtaining numerical results.

5. If the truss is over-constrained or under-constrained, a dialog box will appear with the appropriate warning and the program will return to the wire-frame mode.
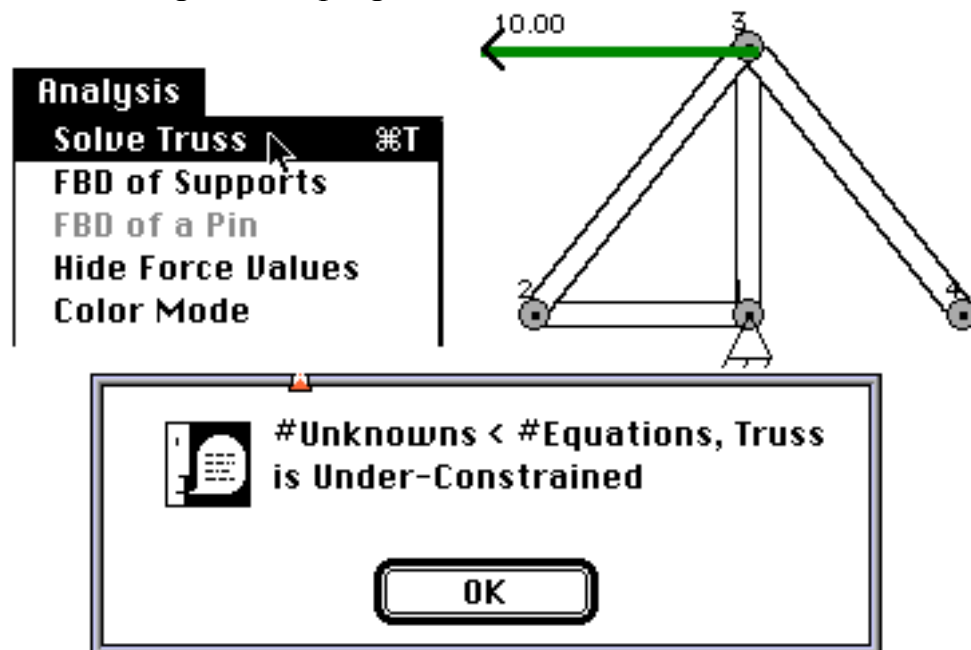
10.00

Analysis
Solve Truss   ⌘T
FBD of Supports
FBD of a Pin
Hide Force Values
Color Mode

#Unknowns < #Equations, Truss is Under-Constrained

OK

Fig. 15. An improper truss missing a support (indeterminate)

2.4 Method of Joints

There exist two popular methods to analyze a truss: The Method of Joints and the Method of Sections. The Method of Sections will be discussed later.

To start the Method of Joints click the shortcut button. To see the free body diagram of a joint simply select the node and hold the mouse button. The forces will disappear as soon as the mouse button is released. See Fig. 16 for an illustration.
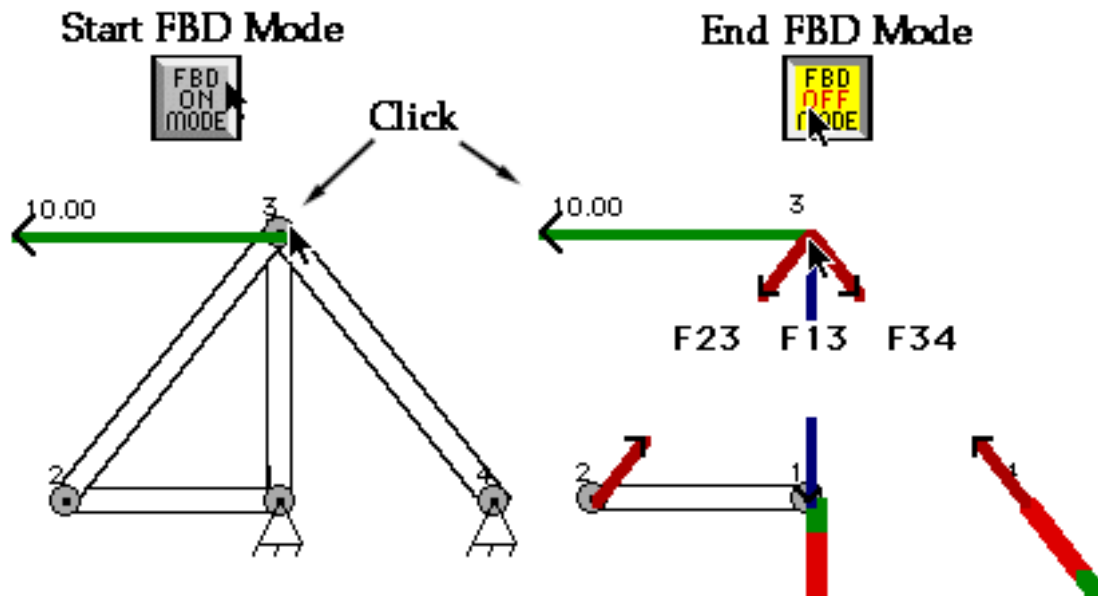
Fig. 16. Implementing the Method of Joints

2.4 Method of Sections

The Method of Sections can be used to find the free body diagram of any member. Usually this method is used to split the truss into two segments when the method of joints would fail in case of an indeterminate truss or a truss with redundant members. This method will produce the free body diagram for both pieces of the truss.

To start this procedure click the method's button.

New buttons will appear that would control this method .

Select the members that you want to cut through and click DONE to see the free body diagram. Choose RESET to restart the process or terminate it with the OFF button. See the figure below for an illustration.
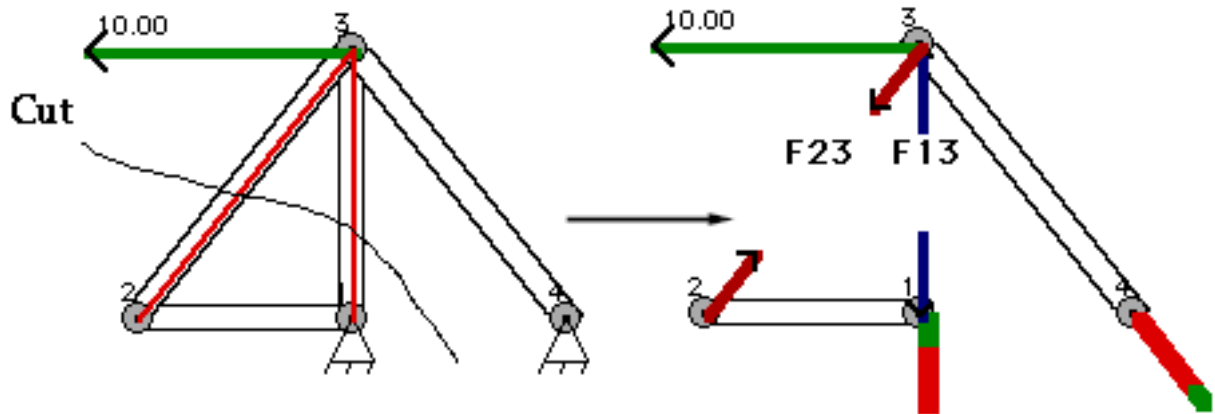
Fig. 17. Implementing the Method of Sections

Note that the cut has to completely separate the truss into two independent sections for the method to be meaningful. The application does not check if the cut is complete. It is the user's task.

3- EXPORTING RESULTS

Truss 5.0 supports several result exporting options:
A) The main screen could be copied to the clipboard and pasted in another application.
B) The windows can be exported as a PICT file from the "Window" menu.
C) A QuickTime movie can be created to simulate a car traveling selected members.
   Select "Export Car Movie..." from "File" menu and enter the desired information in the window:

Show a car traveling over joints:

Adjacent Nodes:
(e.g. 1 3 4 ...)

1 3 4

Nodes in order

Playback frame rate:
(per second)

Load Steps: 30
(between 2 nodes)

Load increments
per member

Max Load: 100.0

Maximum load
to distribute

☐ **Show Applied Force**

Display force distribution
in the animation

○ 1
◉ 8
○ 10
○ 12
○ 15
○ 24
○ 30

Movie rate

[Cancel]   (OK)

Fig. 18. QuickTime movie options

The resulting movie can be viewed with any application that supports QuickTime format like SimplePlayer.

QuickTime™ and a
Graphics decompressor
are needed to see this picture

Fig. 19. QuickTime movie (double click to view)

D) If desired, The individual frames could be saved as a series of PICT files that could be assembled with other applications like MoviePlayer from Apple. To do so, choose "Export Car Movie Frames..." from the "File" menu.

Note: To change the car in the animation, design you own and replace the appropriate application PICT resource with ResEdit.

4- MENU OPTIONS

About Truss...		Display credit logo
Help...	⌘H	Show on-line help
Why the Beep...	⌘/	Explain beeping

File		
Save Truss...	⌘S	Save settings in an input file
Open Truss...	⌘O	Load the truss from an input file
Read File...		List a text file in the console
Invert Screen		Toggle background between black and white
Copy...	⌘C	Copy selection to clipboard
Print Window...	⌘P	Print the top window
Export Car Movie...		Produce a QuickTime movie
Export Car Movie Frames...		Save movie frames as PICT files
Quit	⌘Q	Exit application

Edit

Erase Design		Erase the screen and initialize the problem
Create Truss		Create a triangle which is the basis of the truss.
Add a Node	⌘A	Add a node between 2 selected joints
Delete a Node		Remove the selected node
Add a Member	⌘L	Add a member between 2 selected joints
Delete a Member		Delete a selected member
List Parameters		Display information about the design in console
Member Width...		Change the members' width
Hide Node Numbers		Hide/show node numbers

Analysis

Solve Truss	⌘T	Solve for the member forces and show colors
FBD of Supports		Show the free body diagram of the supports
FBD of a Pin		Show the free body diagram of a selected joint
Show Force Values		Show/hide force values
Mode		Color or wire frame mode
Truss 1	⌘1	
Truss 2	⌘2	
Truss 3	⌘3	Preset truss examples
Truss 4	⌘4	
Method of Joints		
Method of Sections		Start analysis method
Write Analysis Steps		Write the solution procedure to a file
		(Gauss-Jordan matrix solver with pivoting)

Grid

Grid Size...	⌘G	Set grid spacing in pixels
Show Grid		Show/hide grid
Align Truss Members		Align any minor crookedness in the members
Snap Nodes to Grid		Snap the joint to the closest grid
		(if it is fairly close)

Window	
Truss	
Force List	Bring window to the front
Console	
Color/Pattern Mode	Use solid/pattern colors to show forces
Export Window as PICT... ⌘E	Export the front window as a PICT file

5- SHORT CUT BUTTONS

Operations on a selected joint:

- Install pin support
- Remove support
- Y-Roller support
- X-Roller support
- Add/remove a force
- Remove node (and connected members)

Operations on 2 selected joints:

- Add a member
- Remove a member
- Add a node (and two members)

Other operations:

Move truss in arrow direction

Toggle Color and Wire Frame modes

Activate FBD mode   **Return to normal mode**

Activate Method of Sections

Return to normal mode

Select members and click to cut

Restart method