

Kinematic Land Tutorial

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Feb 13th 1997

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1 What is Kinematic Land?

The aim of Kinematic Land is to make kinematic analysis in a straight-forward manner. The Macintosh platform is a great choice to interact with the user, because of its well-known friendly interface; but kinematic analysis isn't something anyone could afford. It requires some competences with the subject and it even wants the user to think with some typical patterns to build correct kinematic models.

1.1 Kinematic Land's documentation

Kinematic Land is a work in progress, the code and the documentation, though the work of documentation goes slower than coding. Kinematic Land's document resources are shared in more supports. The track Tencas Group is following for the documents is to create and maintain four main documents:

- Apple Guide online help
You may consult this help, while using your copy of Kinematic Land. You have fast answers to the common questions about Kinematic Land's features. This online help needs Apple Guide installed in Extensions folder.
- Tutorial PDF file
This document contains basics about Kinematic Land and general information about its features.
- Reference PDF file only for registered users
This resource has full technical notes, detailed guide to any Kinematic Land's feature and even exhaustive theoretical chapters about mathematics regarding kinematics. This guide is available only for registered users. As soon as you register your Kinematic Land's copy to Kagi (<http://www.kagi.com>) with Register application and you provide your Email address in the registration form, Tencas Group will send you this PDF file via Email as file attachment.
- Programming resources in PDF format only for developers
This resource is intended only for internal development of Kinematic Land for now. It will be probably extended as soon as we expand Kinematic Land with more sophisticated functionalities and we rationalize Kinematic Land's modular design.

1.1.1 Restricted documentation

PDF files and Kinematic Land's documentation are under development. You may encounter some defective information in these documents. We started composing the laborious work to documents, though it requires a lot of patience and time, but we wanted to distribute an overview of what Kinematic Land's documents are to become. Some pictures could be missing, because they could enlarge the PDF sizes very much or we haven't prepared them at all.

2 Requirements

This section presents what kind of Macintosh you should get in order to get decent performance from Kinematic Land.

2.1 Minimal requirements

- System 7.0.
- RAM: 1500 KB available for Kinematic Land.
- 32-bit Color QuickDraw.
- 68020 processor.
- QuickDraw 3D 1.0.6 (only for PowerMacintosh).

2.2 Suggested requirements

- System 7.5 or higher.
- RAM: 3000 KB available for Kinematic Land.
- AppleGuide.
- PowerPC processor.
- QuickDraw 3D 1.0.6 (only for PowerMacintosh) or newer.
- QuickTime 2.0 or higher.

3 Let's start...

This section will introduce you Kinematic Land basics. We'll guide you rapidly how to make Kinematic Land running with your Macintosh.

3.1 Unstuffing and installing Kinematic Land

You probably already have unstuffed and installed Kinematic Land, but you should also be able to repeat this procedure with another Macintosh. We divide this process into two procedures, depending on the fact we downloaded the stuffed archive from the Internet or you got Kinematic Land from a CD-ROM.

3.1.1 From the Internet

If you have downloaded Kinematic Land from some Info-mac mirror, you should have a .hqx file somewhere in your hard disk. It could be already unbinhexed by your ftp program, so that you have a .sit file. Drag one of this files to Stuffit Expander's icon or double click one of the files if you have Stuffit Lite or Stuffit Deluxe in your hard disk. The unstuffing procedure is the same of unstuffing any file found on Info-mac. The unstuffing application may also ask your for the destination of Kinematic Land folder: choose the right location for Kinematic Land, so that you easily remember where to find it.

3.1.2 From some CD-ROM

You probably got an installed release of Kinematic Land in some CD-ROM shareware collection. You have only to copy the whole folder to your faster hard disk, otherwise Kinematic Land runs also from CD-ROM, but its performance could be slower than from the hard disk.

3.2 Running Kinematic Land

You may double click the Kinematic Land icon and it should start. You might even double click any Kinematic Land document located in the chains folder or the 3D chains folder; the Finder should have launched Kinematic Land and told it to open those documents. If you haven't been able to launch Kinematic Land, please refer to sections 8.1 and 8.1.2.

3.2.1 Empty document

As soon as Kinematic Land has started up, it should already have opened an empty document. This document is ready to edit.

3.3 Opening a document

You have just to choose *Open...* in the *File* menu. Kinematic Land will open a standard dialog and you'll navigate to find the file you are intended to open. You might open some example included with Kinematic Land in *3D chains* folder or in *chains* folder.

3.4 Quitting Kinematic Land

You have just to close the application with Quit command in the File menu. Kinematic Land will eventually ask you for confirming to save the currently open documents that haven't been saved yet.

4 Fundamental assumptions

Kinematic Land and kinematics, in general, requires you to start thinking mechanisms like a sort of equations. This isn't a great goal for software written for Macintosh, but you'll discover that's not true and Kinematic Land tools offer you a good advantage to model complex mechanisms with minimal effort.

4.1 Let's thinking kinematics...

Tencas Group is working on this subsection...

4.2 Discrete simulation

Kinematic Land calculates discrete simulation, that means Kinematic Land solves the problem at time t , assuming that independent variables are defined for any time. This is natural scheme of the discrete simulation:

- the core gets the time value t
- it calculates any independent variable at time t
- it builds the problem
- it solves the problem
- it stores the possible solution somewhere

Kinematic Land's user interface follows this pattern:

- the interface establishes how to increase t , as the user set the time settings:
 - it increases t to $t + \delta t$ or
 - it gets the natural clock from the system software
- the interface invokes the core
- the interface updates any window with the last results.

4.3 Natural coordinates

Kinematic Land processes its computations, by assigning to the scene a mathematical point for any interesting joint, with its three coordinates, and could also assign another vector, the *unit vector*, around reaching members could rotate which. *Unit vectors* have three coordinates too, though the module of them is unity, because they are normalized by Kinematic Land. Any point could have upto six parameters to be computed, depending on how you build the scene, where the point coordinates always exist in the kinematic problem. When Kinematic Land tries to resolve the kinematic problem, it will build the equations from the constraints you have forced in the scene, assuming that these six parameters are unknown for any interesting joint of the scene.

4.3.1 Why did we choose natural coordinates?

We chose natural coordinates, instead of other coordinate representations, because we evaluated some opportunities and at last we followed the suggestions of García De Jalón-Bayo in their comprehensive book *Kinematic and Dynamic Simulation of Multibody Systems*. Please refer to this textbook for theoretical foundations on kinematics and dynamics.

4.4 Constraints list

Tencas Group is working on this subsection...

4.5 Computation of solutions

Tencas Group is working on this subsection...

4.6 Modeling joints from other software or mathematical theories

Tencas Group is working on this subsection...

4.7 Separation between core and interface

Tencas Group is working on this subsection...

5 Interface

Here it is how to use the tools and what they do.

5.1 Views

Different windows are available in Kinematic Land. In some windows you may interact with the scene, creating, dragging, modifying any item. Other windows are useful to keep an eye on critical values.

5.1.1 Plan views

You may distinguish these windows by their title. The prefix of the title indicates the document name, then you can find how much that view is zoomed and, at last, you can understand which plan you are observing to. Three plan views are, of course, available:

- Front View
- Top View
- Left View

5.1.2 QuickDraw 3D view

This window is only available on PowerPC-equipped Macintoshes. This is due to the fact that this window calls the QuickDraw 3D, that runs only on PowerMacintosh. It contains a standard QuickDraw 3D viewer, with some standard buttons. The viewer's icons vary depending on which version of QuickDraw 3D you have installed on your Macintosh. Here it is an example of this window:

Tencas Group is working on this subsection. . .

5.1.3 Displays

You may open as many windows as you want, that show you the value with respect of time progress. These windows are called *Displays*. The only limitation imposed is the memory free. Any *Display* robs about 5 KB, but it shouldn't be a problem. In these windows Kinematic Land plots any quantity: coordinates, speeds, accelerations of any point of the scene or it also plots angles, relative speeds, angular speeds, relative accelerations and even angular accelerations of any couple of points.

5.2 Available tools

Several tools are available in the tools window. Tools in the tools window could be displayed with different icons, depending on some conditions. Suppose to see at one of these different icon representations of the arrow tool:

- the arrow tool is activated
Its icon should appear deeper than other tools. It is the currently activated tool.
- the arrow tool is normal
The arrow tool may be activated, if you click on it.

- the arrow tool is greyed out
The arrow tool can't be selected, because the document doesn't enable this tool. Some tools could be selected by the user, only if certain conditions are satisfied.

5.2.1 Arrow

The *arrow* tool selects points and members or drag them.

5.2.2 Zone selection

The *zone selection* tool selects any constraint with any point in your drawn rectangle. The points of the kinematic chains inside the rectangle become highlighted.

5.2.3 Hand

The *hand* tool lets you drag the content of the window. You can modify the center of your scene. You may modify the center of the scene also with window bars.

5.2.4 Alpha

The *alpha* tool forces the angle between the selected points to be fixed. This angle is the angle between the straight line over the two points and X-axis.

5.2.5 Lens

The *lens* tool reduces or magnifies your view on the chains. Magnifying ratios go from 50% to 1600%.

5.2.6 Distance

The *distance* tool creates a member without unit vectors, so it forces the distance between two points to be fixed. You have to drag the segment between them. It will be automatically defined its length.

5.2.7 Member with one vector

The *member with one vector* tool lets the user create a member dragging its length. The first point you click is the point which the member rotate around.

5.2.8 Member with two vectors

The *member with two vectors* tool lets the user create a member dragging its length. If no unit vector exists at the first or the second point, Kinematic Land automatically will add one or two constraints to the constraint list. These constraints force the unit vectors to have unit module.

5.2.9 Align

The *align* creates an alignment constraint between three points of the kinematic chain. The tool is disabled if the selection contains less or more than three highlighted points. The points will be forced to be aligned.

5.2.10 Revolute joint

The *revolute joint* tool lets you add a new unit vector in the point you have selected. This unit vector isn't fixed. You can lock it with the *blocked unit vector* tool or editing this unit vector with the *Set unit vector...* menu item.

5.2.11 Cylindric joint

The *cylindric joint* tool lets you add two unit vectors in the highlighted points. You force these unit vectors to be parallel.

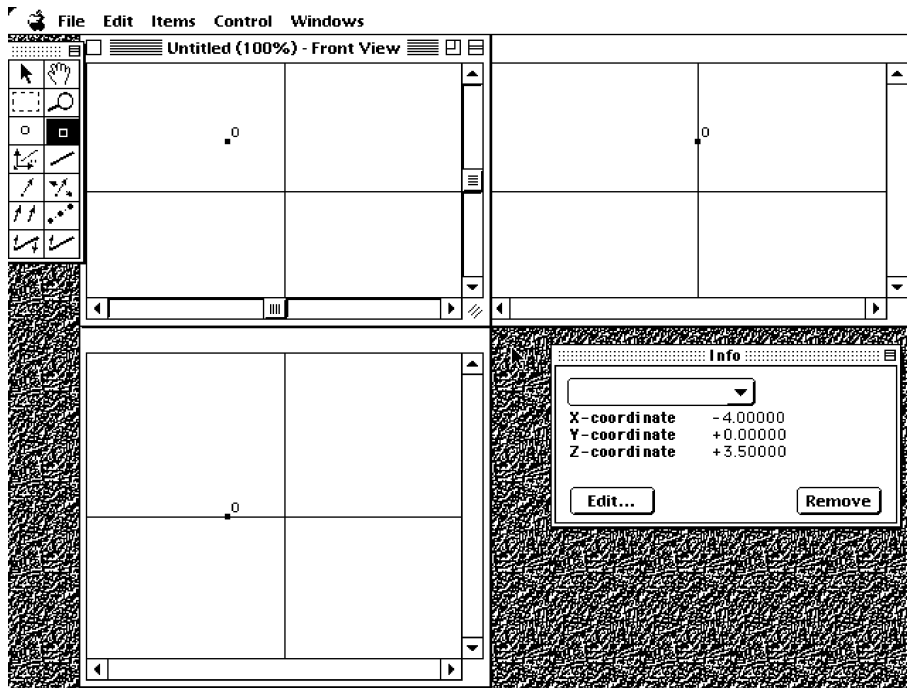
6 Examples

The better way to understand Kinematic Land's facilities is to model some mechanisms.

6.1 Moving point

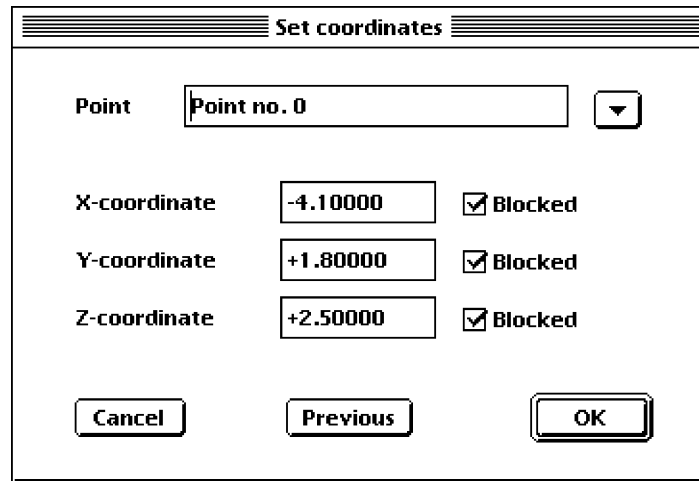
This first example will guide you creating the same scene of *Moving point* file in *3D chains* folder. Suppose you have already opened an empty document and three plan view windows are topmost.

Select the *Blocked point* tool and create a point in one of the three plan views, the *Front View*, for example.



The document should appear like picture 6.1. Please also check in *Info* floating window to see how many constraints are queued in the *Constraints list*. Only one constraint, *Point coords [0]*, should be present. This constraint forces point no.0 to have fixed X,Y and Z-coordinates at the coordinates where the mouse was positioned when you created the point. You may also drag the current point to another position. You should change the current tool, from *Blocked point* to *Arrow*, and double select point no.0. If you click again onto point no.0 in the current plan view, a doubled selection, represented by a bigger black rectangle, should appear. Then drag the point to another destination in the same window. If you can't interact during this dragging action, please refer to section 8.3. In the current plan view, the *Front View*, you are not allowed to modify the Y-coordinate of the point. In this plan, you can only modify X and Z-coordinates of any point. If you aim to change even the Y-coordinate of point no.0, you have to change plan view window, to *Top View* or *Left View*. You can drag the current point also with respect of Y-axis in these two windows. If you run

the current scene with *Run* item in *Control* menu, the animation is “static”: you created a point and you forced it to be motionless because of the `Point coords [0]` constraint. To stop the current animation, please click everywhere in one of Kinematic Land’s open windows or press `Cmd- .` shortcut. We’d like to bring to life the scene, adding some live constraint, a constraint that forces some quantity to vary while time is running. First of all, you need to remove one “static” constraint, the X-coordinate. You have to open the *Set Coordinates...* dialog from *Items* menu:



You should note that any coordinate of point no.0 is blocked, because of having previously created with *Blocked point* tool. Let us disable the *Blocked* flag of X-coordinate. After accepting this modify with *OK* from this dialog, you may check the *Constraints list* in the *Info* floating window.

The last `Point coords [0]` constraint has been removed in favour of two newer constraints, `Y-coordinate [0]` and `Z-coordinate [0]`. The comprehensive `Point coords [0]` constraint generated three equations in the kinematic problem, while, because of the lack of the blocked X-coordinate, two simpler constraints are needed to build the kinematic problem.

If you try to run the scene, you’ll get the “*Lacking constraints.*” alert box. Your scene needs three constraining equations to allow three point coordinates to be found, while only two equations compose the kinematic problem.

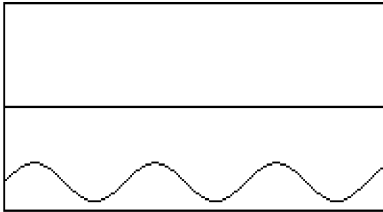
You need to add another equation to get the kinematic problem to be solved. Let us add an independent variable with *New Free Dialog...* item in *Items* menu. This dialog lets you create an independent variable to follow constant, physic, sinusoidal evolutions. Choose *X-coordinate* as *Free quantity*, *Point no.0* as *Item* to identify which quantity you are creating. Then specify the values for this varying variable, setting any value in *Initial position*, -8.00000 as picture 6.1, and enabling its flag, disabling *Initial speed*, *Constant* and *Linear term of Accelerating term*, enabling *Frequency* and *Module* flags and assigning them some nonzero values, +5.00000 for frequency and +2.00000 for module.

Free variable

Free quantity: X-coordinate

Item: Point no. 0

<input checked="" type="checkbox"/> Initial position	-8.00000	<input type="checkbox"/> Constant	+0.00000
<input type="checkbox"/> Initial speed	+0.00000	<input type="checkbox"/> Linear term	+0.00000
		<input checked="" type="checkbox"/> Frequency	+5.00000
		<input checked="" type="checkbox"/> Module	+2.00000
		<input type="checkbox"/> Phase	+0.00000



Remove
Cancel OK

If you confirm the creation of this independent variable, please press *New* button. You just entered in the *Constraint list* a newer constraint, *Free X-coordinate [0]*. This constraint will force the kinematic problem that X-coordinate of point no.0, will be:

$$x_0(t) = -8.00000 + 2.00000 \sin(5.00000t)$$

This constraint resumes the size of the kinematic problem to be equal to the number of the constraints. The solution could be approached by Kinematic Land's core and you could run the animation with *Run* in *Control* menu.

6.2 Crank

6.3 Stewart

7 Directions

Where does Kinematic Land go in future ? Here are some guidelines we are following for future enhancements of Kinematic Land. If you have some original ideas to suggest to Tencas Group, your contributes will be very appreciated, but think also to registering your Kinematic Land's copy and your generous contribute will be more and more appreciated.

7.1 Enhancing the user interface with PowerPlant

The Metrowerks's PowerPlant framework has already taken into consideration to clean up some programming troubles of Kinematic Land. We hope to have some time to schedule and port original Kinematic Land's application framework to the newer PowerPlant's.

7.2 Introducing the expression editor

Any independent variable in Kinematic Land could be varying in the time following user's preferred evolutions. In any dialog, where you set some distance, angle or any other quantity, you may open an additional dialog to set that variable progress choosing between this range:

- constant values
- physic values
- values dictated by any mathematical function
- values imported from file
- values piloted by any file

That additional dialog will be richer than current *Free Variable...* dialog and it will unify some current separated modes to force the progress of some independent variable.

7.3 Enriching the QuickDraw 3D capabilities

The QuickDraw 3D viewer will remain a window where you can only view the scene, instead of interacting, moving and dragging items. The scene will be indeed rendered with more detailed attributes, so that you could identify kinds of joints and you also give some sizes to the objects.

7.4 Kinematic and Dynamic Markup Language

We also accumulated some experience with SGML language, so we are thinking to invent another application of SGML. It is to be called *KDML* (Kinematic and Dynamic Markup Language) and it will be very useful to build complex scenes of kinematic and dynamic problems. These language will allow the user to open and save KDML's files and even edit them. These files won't be binary, but plain texts, letting the user to customize their kinematic scenes.

7.5 Expanding import/export with other software

Kinematic opens and saves its own binary format, which can't be penetrated, if you haven't Kinematic Land's source code. It provides to export to two popular standard formats.

7.5.1 QuickTime movie

The QuickTime movie is generated from the current plan view. The user may set also some properties of the QuickTime generated file, such as the number of frames per second.

7.5.2 QuickDraw 3D metafile

You can only copy into the clipboard the scene displayed in the QuickDraw 3D view. You may also save it as standard QuickDraw 3D metafile. We are evaluating how to import other QuickDraw 3D metafiles generated by other QuickDraw 3D-savvy applications.

7.6 Porting Kinematic Land to Windows 95/NT

Only one request has come to port Kinematic Land to the Windows platform. We are evaluating if somebody could make the job, because our Windows experience is very limited with respect of the Macintosh platform. We also like to keep Kinematic Land unique for the PowerMacintosh platform, so that Macintosh users are privileged.

7.7 Adding multiprocessing power to Kinematic Land

Apple and Daystar have defined what are the guide-lines to follow in order to get your application MP-aware (multiprocessor-aware), i.d. it uses more than one processor if your PowerMacintosh has more than one PowerPC processor. Kinematic Land makes a lot of mathematical computations and these MP-capabilities could be activated in order to maximize its performance.

7.7.1 Kinematic Land is already MP-aware...

If you have installed QuickDraw 3D 1.5, which shipped in mid-November '96, or newer, Kinematic Land is already MP-aware, because it makes function calls to the QuickDraw 3D Viewer, that uses more than one processor if found.

7.7.2 ...but it will be more MP-aware

The core that calculates the Jacobian matrix of the problem, some other code pieces that multiply matrices and invert them, could be optimized with the *divide-and-conquer* technique. We hope to release Kinematic Land MP-aware in the next release.

8 Troubleshooting

We divide this section into problems, so that we can formulate them once and we can give some solutions or workarounds to avoid them.

8.1 Kinematic Land won't start with my Macintosh

8.1.1 Kinematic Land won't start with my 680x0 Macintosh

You should check that your Macintosh satisfies minimal requirements. If you haven't Color QuickDraw, Kinematic Land refuses to run.

8.1.2 Kinematic Land won't start with my PowerMacintosh

A lot of PowerMacintosh users haven't enabled QuickDraw 3D or they simply never installed it. Kinematic Land wants that QuickDraw 3D shared libraries are present in Extensions folder and it tries to activate them at its start up, otherwise it will tell you it hasn't found those libraries.

8.2 Where can I find QuickDraw 3D?

QuickDraw 3D could be retrieved in several points; please evaluate which is the best way for you.

- System disks or system CD-ROMs
If you have a PowerMacintosh, you should have also QuickDraw 3D in your system CD-ROM. The negative drawback is that QuickDraw's release could be old.
- Shareware CD-ROMs
Apple permits a lot of shareware and commercial software distributors to put QuickDraw 3D in their CD-ROM collections. Please look at your shareware library.
- QuickDraw 3D's Apple site Apple has a server dedicated to this technology. Please have a look at:

`http://www.quickdraw3d.apple.com`

and you'll get more resources and URLs to download the latest release of QuickDraw 3D.
- FTP Apple site Apple keeps several ftp sites containing a lot of system resources. For European people, downloading could be faster from the European mirror:

`ftp://ftp.info.euro.apple.com/Apple.Support.Area/`

8.3 I can't drag anything

You aren't able to drag any selection or you can't interact while dragging the mouse. The reason is that *Interactive dragging* in the *Preferences* dialog is disabled. If you enable the *Interactive dragging* option, Kinematic Land lets you see how the scene is modified at your fingers, provided that the scene has already been calculated with one reasonable solution before dragging.

8.4 I can't open correctly some document

8.4.1 Why do I get the message "This document seems to be created with an older release of Kinematic Land. It will be updated if saved."?

You are probably opening some example file in *chains* folder. These files have been saved with the older Kinematic Land's 1.2 release and they show planar kinematic mechanisms. They haven't been updated to the last release in order to show Kinematic Land is able to upgrade older files. You could encounter this message at the opening of some kinematic mechanism you edited with previous versions of Kinematic Land.

8.4.2 I try to open some mechanism edited with an older Kinematic Land's version and it can't run

Kinematic Land isn't sometimes able to convert older Kinematic Land's documents. It's better you edit the scene again, otherwise you may send your document to Tencas Group and they will try to convert the file for you.

8.5 Other troubles?

For any other trouble you encountered with Kinematic Land, you may contact Tencas Group and explain via Email what's your trouble or what's the bug you found. Please refer to section 9.

9 How to contact Tencas Group

The best and faster mode to contact Tencas Group is to send a message via Email to:

- tenuti@dei.unipd.it

This Email account is to be discontinued in next months.

- tencas@kagi.com

Tencas Group adherits to the Kagi Shareware circuit, that provides support to register a lot of Macintosh applications. This Email forwards the messages directly to Tencas Group.

If you like to get the lastest news about Kinematic Land, please try also to look at Tencas Group's WWW home page at Kagi site:

<http://www.kagi.com/authors/tencas/>

or temporarily you even may try at my private home page:

<http://www.dei.unipd.it/~tenuti/>

My snail mail:

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