A Rough Guide to the KnotPlot Demos

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KnotPlot comes with a wide variety of demos that you can access using the DemoA and DemoB tabs on the KnotPlot Control Panel. Some of these demos are "serious" and intended to illustrate important concepts in Knot Theory. Others are less so and are designed to be playful or decorative. A few of the demos are fairly deep exploratory tools, that can be quite engaging for the entrepid knot enthusiast. Others are simply a waste of time. Most demos are randomized to some extent and this means you will see something different everytime you run them. Some demos have a large amount of random variation, some have little (or even none). Click and find out!

This document briefly explains the point, if any, of most of the demos. It is organized by sections, starting with the Knot theory section on DemoA.

Knot theory

guess knot — Try to guess which of the two objects you see is really knotted. One of the objects can be smoothly deformed into a circle without having the string pass through itself (so it's an *unknot*). The other cannot (being a *non-trivial knot* called a *trefoil*. This is an illustration of the most important problem in knot theory: when is something really knotted? This is known as the *unknotting problem* and is actually a difficult problem.
Things to try: (1) use the compare to... buttons to compare the two objects before clicking on find out!. (2) After running the demo once, try changing the point of view (left click and drag in the main view window and rotate the knot) and then reload the knot (or unknot).

Nasty — Similar in function to guess knot but whether or not this beast is really knotted might be more obvious.

Perko pair — A famous pair of knots that were listed as distinct knots in knot tables until Ken Perko showed in 1974 that the were in fact the same knot. His proof consisted of a sequence of knot diagrams. This is a different proof by KnotPlot. The knots start out in different conformations and end up looking exactly the same. The *knot equivalence problem* turns out to be even more difficult than the unknotting problem previously mentioned.
See knotplot.com/perko

Brunnian — Starts off with five round circles and a string interwoven through them. Click on run animation to find out what happens. This is a link that has the *Brunnian Property* (after the mathematician Brunn). The individual strings in a link with this property cannot be separated.

However, *if any one string is removed*, the others fall appart. Follow the on-screen instructions and see if this is true.
See knotplot.com/brunnian and knotplot.com/brunnian/borromean-rings.html

random braid — Related to knot theory is *braid theory*. Braids are special kinds of knot diagrams, of the type you see when you click on the random braid button. Any knot can be constructed by closing some braid.
knotplot.com/knot-theory/braids.html has the beginnings of an explanation

Redm. moves — The three fundamental moves in diagramatic knot theory. In a sequence of knot diagrams drawn on a piece of paper, two knots are equivalent if and only if you can convert one diagram into the other via a sequence of Reidemeister Moves.[1]

chirality — Some knots are the same as their mirror image. Most are not. This demo has a proof that one of the knots is equivalent to its mirror image. Such a knot is called *achiral*. The other knot may or may not be equivalent to its mirror image.[2] Most knots are not achiral and cannot be smoothly deformed into their mirror image. These are known as *chiral* knots.

twist knot — Shows how a particular family of knots, the *twist knots*, are constructed.

torus knot — Another family of knots, the *torus knots*, are those knots that can be drawn (or wrapped around) a torus.
For a pretty picture, visit knotplot.com/knot-theory/torus_xing.html

Lissajous — Yet another infinite family of knots, the *Lissajous knots*. These knots have a fairly simple formula.

tangles – Embed little tangles into a *tangle holder* to create complex knots and links. The tangle holders are mostly due to John Conway (he called them *basic polyhedra*.

rat tangle — Illustrates how a class of tangles, the *rational tangles*, are created.

stick knots — Might be broken.

ACN1, ACN2 — Visualizations of how the *Average Crossing Number (ACN)* is computed. ACN1 is static whilst ACN2 is dynamic (try tugging the knot around, instructions are given).

Fig-8 symm — A badly implemented demo that fails to show the beautiful rigid geometrical symmetry of the Figure-8 knot.

BB frame — Contructing the *blackboard framing* of a knot. Doesn't always work.

moebius — Performs *Möbius inversion* through a 2-sphere.

magnetic — Shows what part of the magnetic field lines around a knot would look like if the knot were a current carrying wire.
Things to try: (1) Click on two rings or hopf link and then hover your mouse over one of the strings until you see some text appear. Then click your mouse to reverse the current in that string. Observe the change

[1] Along with smooth deformations of the paper.
[2] The other knot is the trefoil and it's not equivalent to it's mirror image, but this is not so easy to show.

in the magnetic field. (2) If things drift apart, click on collide.

DT code — Interactive computation of DT and Gauss codes. These are topological encodings of a knot diagram useful in knot classification studies. You can do a lot of things with this demo, be sure to click on the ? button in theKnotPlot View Window.[3]

Constructions

weave — A weaving machine. Click the show / hide weaver button to reveal the weaver. Any knot can be used as a weaver, this demo uses only torus knots.

ringpack — Pack rings until you fill up some space. You can change the ring size and thickness and you can pack things other than rings. Ring packing of this sort is related to percolation theory and also has important applications in studying how DNA molecules are arranged in certain organisms.

hedgehog, crankshaft — An illustration of the *hedgehog algorithm* and the *crankshaft algorithm*, two methods commonly used to create random knots.

chains, rchains — Create knotted chains.

stick things — Seems this is broken too.

kpath — Not terribly interesting. . .

cable, braid warp — Watch a cable knot or a warped braid get constructed. Keep clicking on rerun demo, some of them are fun to watch as they are constructed. Notice that you can rotate the knot as it's being constructed.

shadows — The "shadow" of a knot. The shadow appears to deform, but the knot itself is rigid. It is simply undergoing a smooth rotation and we are viewing its shadow onto a plane.

gravity — Uses the gravity force in KnotPlot. Has three separate sub-demos, the funnest of which is drop. Try clicking on this repeatedly for an hour or more in fullscreen mode.

Lorenz — Unfinished demo of knotted paths along the *Lorenz Attractor*.

THK — Create a family of knots known by the politically incorrect name "Turk's Head Knots". These are constructed from torus knots by forcing the knot to be alternating.

Cubic SAW — Generates a *Self Avoiding Walk (SAW)* on the cubic lattice.

random — One way to create a random knot, but the demo itself is busted.

free drag — Pull a string around in 3D. Try to make a knot!

Hopf — Visualizes the *Hopf fibration*. This demos is quite engaging in fullscreen mode. Click on one

[3]It's a good idea to click on the ? button any time when you see it in the KnotPlot View Window. It's always in the lower right and usually brings up some useful information.

of the seed buttons. Each button produces something different every time you click on it. When in fullscreen mode, press the spacebar to hide or show the text and buttons.

plaits, splaits — Uses the Celtic Knot Construction Engine (CKCE) inside KnotPlot to create complex plaits, somewhat in the Celtic style. "Splaits" are spherical plaits.[4]

star/box — Also uses the CKCE to create star like or boxes with a Celtic flavour.

ant neck — First few steps along the way to the construction of *Antoine's Necklace*, a fractal knot. Note that Antoine constructed this fractal in his imagination and clearly understood its properties nearly half a century before Benoit Mandelbrot claimed to have discovered the concept of a fractal.

trapped — Trap a knot inside a cage constructed using the CKCE.

Relaxations

simple — An assortment of knots undergoing dynamical relaxations. Sometimes the knot explodes. There is little to control here, but some of the knots can be fun to watch.

Fun w Forces — Play with the different force laws that KnotPlot uses to relax knots.

Thing toss — Toss either rings, strings or things through a loop in the centre of the window. After you've tossed a few, click on the follow button to ride along with the tossed object.

Anchors — A poor or at best incomplete illustation of the use of KnotPlot anchors.

Graphs — KnotPlot is not limited to plotting knots. It can also plot graphs, and these can be knotted. The knot theory of graphs is an extension of standard knot theory. It is a relatively unexplored area that has important applications in biology and chemistry.

Split/delete — An illustration of the power of KnotPlot's knot simplification techniques. This uses two opposing processes: getting rid of extraneous string in loose areas and adding extra string in tight spots. All this whilst preventing the knot from passing through itself. This method works well for all the examples seen in the Knot zoo: section on the left of the KnotPlot View Window, with the exception of one. Can you find it? KnotPlot has trouble with this knot, but a hint is given on how to untie the nasty unknot with a little help from the user (you).

Ring toss, Link rings — needs updating

NeverEnding exhibitions

The demos in this section are of a different nature than all the other demos on either DemoA or DemoB in that when engaged, the demos will take over the full screen and run without interrupting

[4]To create your own Celtic Knots, click on the Sketch button on the KnotPlot Control Panel and then click on –> Celtic knotting near the bottom of that control panel.

until one presses the ESC key.

Knots! — The most complete of the eight exhibits. A mixture of serious knot theory and KnotPlot fun. About a dozen or so different sequences. The sequences repeat, but in an unpredictable order.

Fly thru — Fly along knotted roller coasters. Every few seconds, the path changes.

Frenetic — Just what it says.

Poly dance — Similar to Fly thru but only the outlines of the polygons are shown.

Paint 1, Paint2 — Does't work properly on all graphics hardware. On some computers, it will appear to flicker. This is not intentional.

Aum Fly — Aums floating in space.

glue graphs — Knotted graphs with attitude. Watch little circles try to escape the chaotic jumble only to get pulled into the tangled mess. Why are these things so agitated?