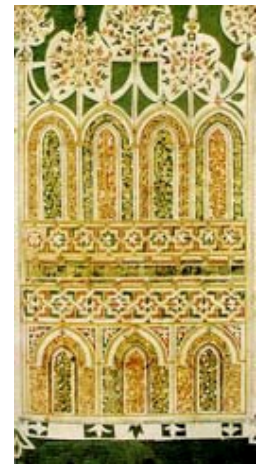


Learn to draw Celtic Knotwork

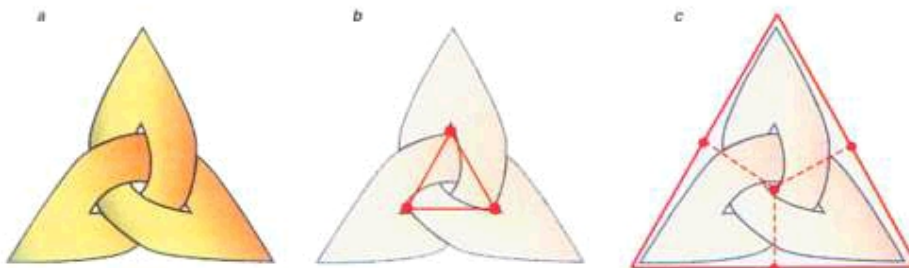


Knots, and more generally, links (when there are several knots), are used in arts for a very long time, for example in medieval enlightened Bibles or Kurans as the Book of Kells, and more recently, in tattoos.



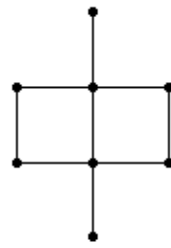
A graph is composed of vertices linked by edges. It is planar when you can draw it without crossings. Each planar graph codes a knot (a link).

For example, the trefoil knot is associated with the triangle.



Graphs are easy to draw. A large class is even called "child drawings" by mathematicians.

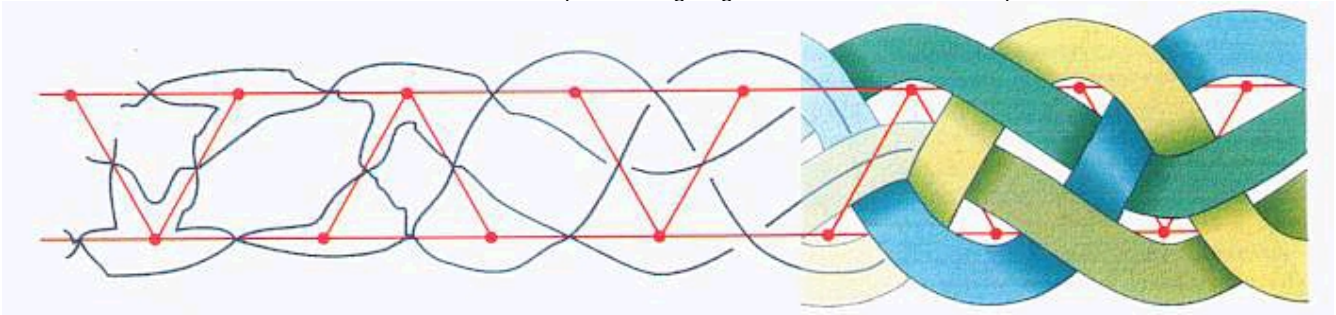
Here is a graph:



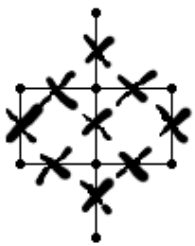
The procedure to build the knot it encodes has four steps:

1. Put a crossing on the middle of each edge.
2. Connect the bits.
3. Stress the over and under crossings.
4. Enlarge the threads.

Here are the four steps we are going to work out on our example

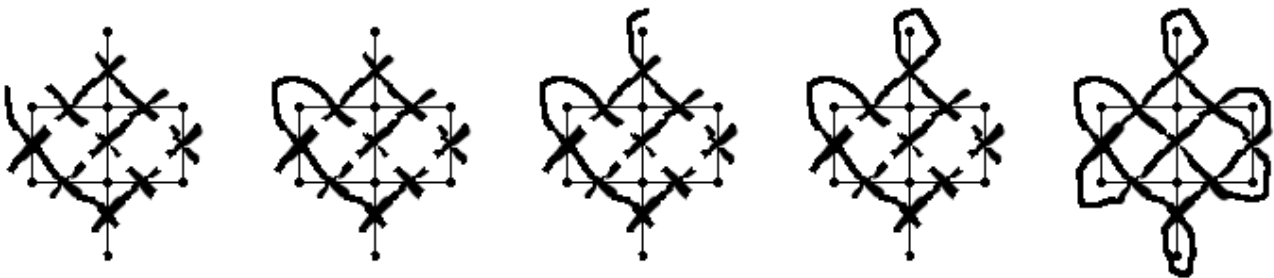
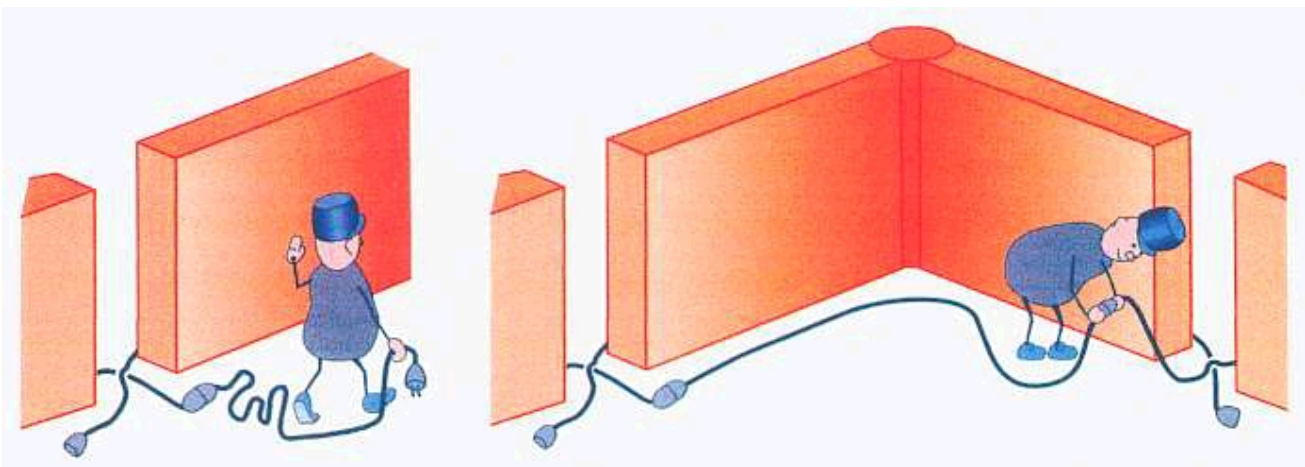


First, put a crossing on each edge:



It is important to draw them clearly so that the direction in which a thread points is unambiguous. In particular, it is not enough just to mark the middle by only one tick, draw both of them.

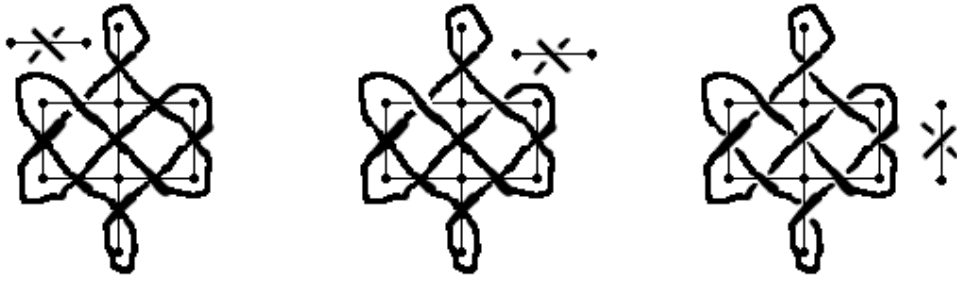
Now you've got to connect the bits to one another. Think of your graph as a **maze** where each edge is a **wall** with a **door** in the middle. On the floor lies the two crossing threads. Choose one bit, it points in a given direction. **Follow the wall**, till you reach a corner, **turn the corner**, **follow the wall** till you reach the next open door. On the floor lies another crossing with one bit pointing towards you. It is where you should connect your thread.



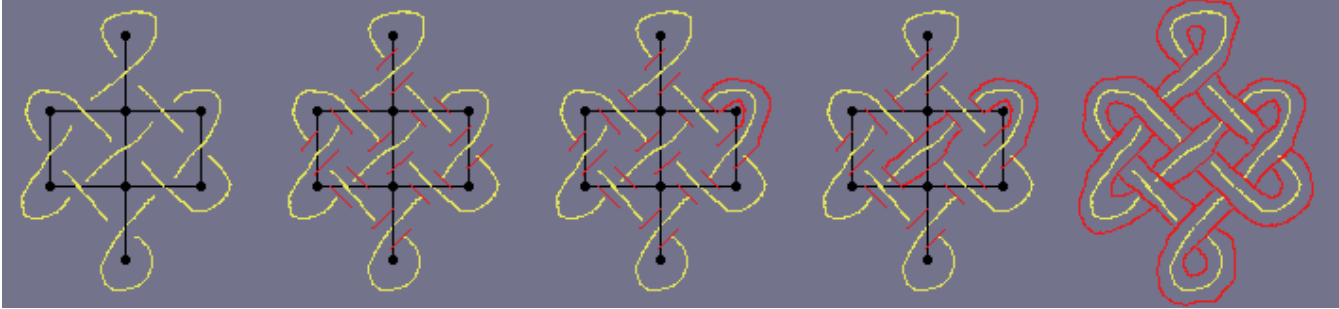
Once you've connected all the bits into continuous threads, you have to smooth them. Don't try and guess too quickly where a thread is leading, apply the method by the book like a good dumb student or else you'll have funny results.

Then, you have to decide, for each crossing, which is the over thread and which is the under thread. You could pick up an arbitrary crossing, decide and follow it along the thread, alternatively over and under. That may work for small designs but for bigger ones, you'll end up with half the design one way, conflicting with the other half the other way... Happily, math provides you with a safe and secure method: Copy this little drawing in the corner of a sheet and tear it off. It is your little guide to figure out your over/under's consistently. Choose an edge and rotate your little guide so that its edge is aligned with the one on the graph. The over/under of the guide tell you which thread is over and which is under!

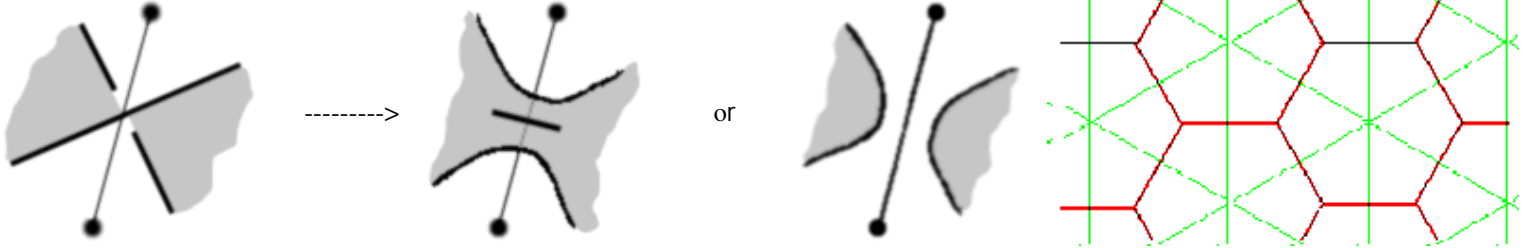




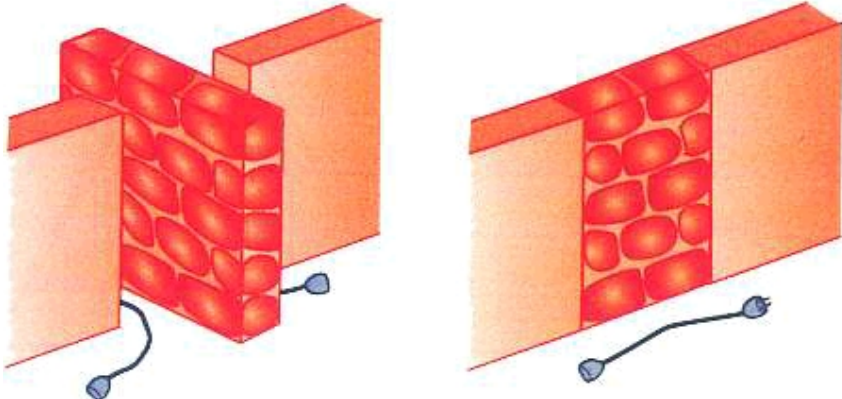
The last step consists in thickening the threads. Think of the thread as the yellow line in the middle of a road and the crossings as bridges. Begin with the bridges, one for each crossing, with a fixed width. Then connect these bridges, drawing each side of the road at a time. This design was used as the symbol of the Ming dynasty.



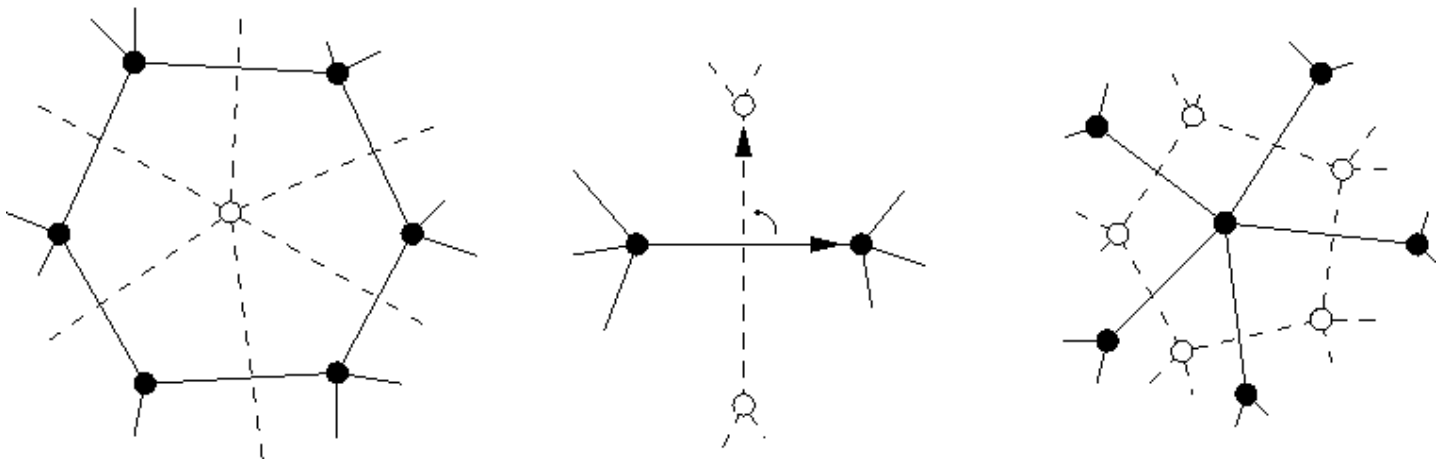
To build a graph is child play. The easiest is to rely on lattices. The most common ones are the square lattice, the triangular lattice, or its dual, the hexagonal, or honey-comb lattice. But they are boring. You have to disturb a bit this regularity by disabling some crossings. It can be done in two ways:



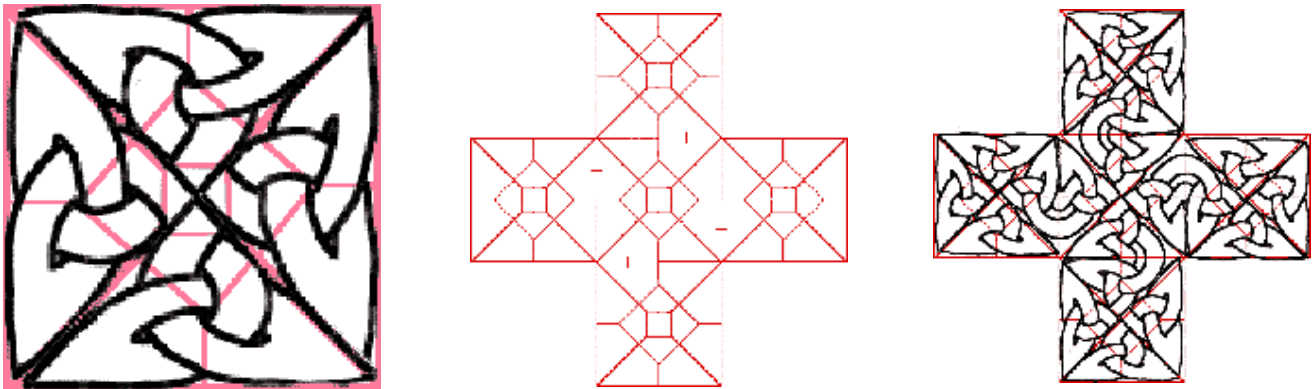
In the maze picture, it amounts to putting a wall in the middle of the door or closing it altogether.



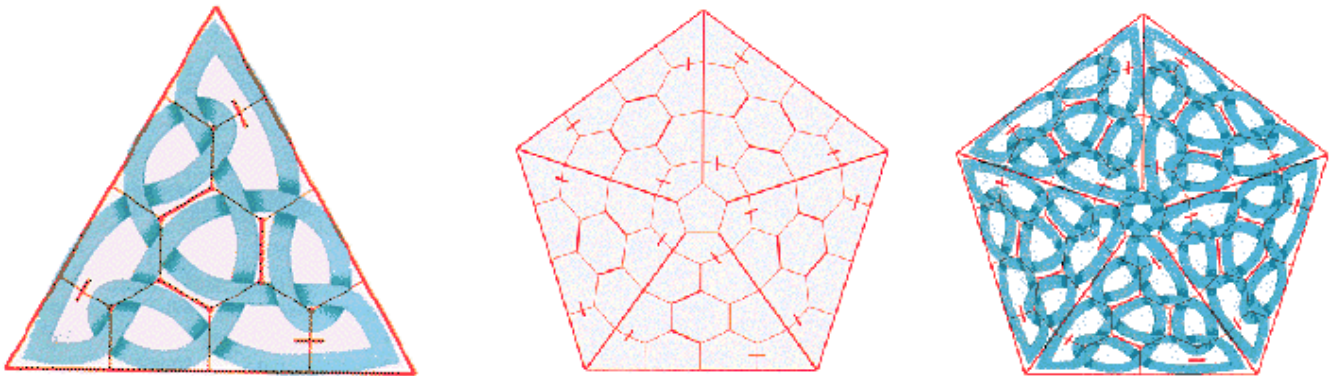
To build larger designs, you have to put your smaller designs in boxes. This is achieved with the aid of the dual graph. Its vertices are in the middle of the original faces and its edges are transversal to the original edges.



It allows you for example, starting from a trefoil, put in a triangle, to build up a cross with four triangles joined together. This cross can then be used to build up yet a larger cross:



The same idea allows you to build a five points star with a triangular design:



The main idea to build a large design is to put nice small knots in boxes using the dual graph construction and then use these boxes to pave the whole area that you want to enlighten.