Mathematical Furniture

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Abstract

I designed Mathematical Furniture in 1995, using only circles and straight lines. The design process is rule-conducted and I call this way of working FORMULA, which in Latin means beauty, rule, guiding principle. In **Mathematical Furniture,** I describe the design of a **Euclidian family of furniture.** The design includes a table, a chair, a cupboard, and three transformations of the ensemble. In **A group of elliptic tables,** I describe the design of a series of tables with a large number of possible leg positions**.** Due to lack of space, some illustrations are not included here but will be shown during the presentation of the paper (Figures PP).

Mathematical Furniture

The Latin term FORMULA means beauty, rule, guiding principle. My working method in this furniture design can be described as FORMULA, because I am applying strict rules and guiding principles in an attempt to achieve beauty. Although it is a rule-conducted design, it does not exclude freedom of expression, which is achieved by defining useful rules and making them workable, and then deciding whether or not to realize the design.
When I began making furniture in 1995, I wondered whether it would be possible to create furniture based on a mathematical concept. With FORMULA in mind, I devised the following rules:
a) the piece of furniture must arise from a single piece of material, without addition or loss (except for sawdust and connecting pieces) and b) the design should be based on a geometric construction.
Simple geometry was used to design two families of furniture based on the circle: 1) a Euclidian family of furniture, and 2) a group of elliptical tables.

1. A Euclidian family of furniture

Geometric construction. The geometric construction can be made in 4 steps.

1. A straight line with a point ***M*** and a circle with centre ***M*** and radius ***r*** are all that is needed to begin.
2. Determine point ***A*** on the straight line at a distance ***r*** from the circle and draw the tangent from ***A*** to the circle. Find ***C***, the point of intersection with the ***Y-axis***, and ***B***, the point of contact with the circle. Then draw the lines ***l*** and ***m*** through ***B*** and ***A***, respectively, perpendicular to the **x-axis**, and draw ***n*** through **C**, perpendicular to the ***y-axis***.
3. Draw a circle with centre ***A*** and radius. and find ***D***, the point of intersection with line ***k***. Then draw the line ***o*** through ***D***, perpendicular to the ***x-axis***.
4. Repeat the constructions for ***l***, ***m***, ***n***, and ***o*** in the other quadrants.

The construction is now complete (Figure PP). Finish by removing unnecessary line elements in it. For the resulting design see figure1.2. I call this type of design Euclidian because it is a geometric design using simple Euclidian tools: a ruler and a compass.

The rectangle shown in figure 1.2 is the plate which will form the table. It is obvious that the length $\boldsymbol{L} = \boldsymbol{4*r}$ and it can be shown that the width $\boldsymbol{W} = \boldsymbol{4/3 * \sqrt{3} *r}$. Calculation of the height $\boldsymbol{H}$ of the table and the angle $\boldsymbol{\alpha}$ of the side parts obtains $\boldsymbol{H} = \boldsymbol{0.958 * r}$ and $\boldsymbol{\alpha = 98^\circ}$. The diagram in the middle shows the design of the table and the diagram below shows the folding and cutting lines. After cutting, the side parts can be moved down along the folding lines so that point ***A*** and ***B*** enter ***M*** (Figure PP). The table design is self-defining and therefore the slope of the side parts is not arbitrarily chosen but is a result.

Figure 1.1: *Core of the Euclidian family*.

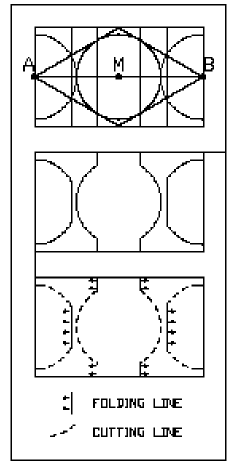

Figure 1.2.

Figure 1.3: *Decreasing length*

Figure 1.4: *Decreasing width*

I designed a chair, a table and a cupboard.The core of this Euclidian family is shown in figure 1.1. The mathematical constructions and designs of cupboard and chair require to much space to be included here. The design can be varied by changing the dimensions. Three transformations were made; by decreasing the width ***W***, the length ***L*** and the diagonal, all by a factor √2. (See figures 1.3 to 1.5). The complete family shown here consist of 3 x 4 members.

I have attempted to show here that using the very simplest design tools, mathematical furniture can be developed.

Figure 1.5: *Decreasing diagonal length*

2) A group of elliptical tables

In 2002, I designed a group of tables employing the same rules as for Euclidian furniture but based on an ellipse.

Geometric construction: (Figure PP).

1. Construct an ellipse with centre ***M***, short axis ***2*r***, and long axis ***4*r***.
2. Construct a circle with centre ***A*** and radius ***2*r***, and find point ***B***. Note that ***B*** is a focus of the ellipse. Now draw line ***k*** through ***B***, perpendicular to the ***X-axis***, and find the point ***C*** where it intersects the ellipse. Draw line ***l*** through ***C***, perpendicular to ***k***.
3. Draw the tangent from ***B*** to the circle and find point ***D*** where it intersects the ***Y-axis***. Draw line n trough ***D*** perpendicular to the ***Y-axis***.
4. Draw a circle with centre ***D*** through ***B*** and find the intersection ***E*** with ***n***. Draw the line ***o*** through ***E***, perpendicular to the ***X-axis***.
5. We have now the lines ***k***, ***l***, ***n,*** and ***o***. Repeat the construction of these lines in the other quadrants.
6. Clean up the picture and view the design.

The rectangle shown in figure 2.1 is the plate which will form the table
It can be shown that the length of the rectangle is ***(6/√3)*r*** and the width is ***(√3/√2)****r The height of the table is ***√3*r***.
This design also contains cutting and folding lines. Choices have to be made in order to construct the table. The slope of the legs is arbitrary.
In the design shown they are perpendicular.

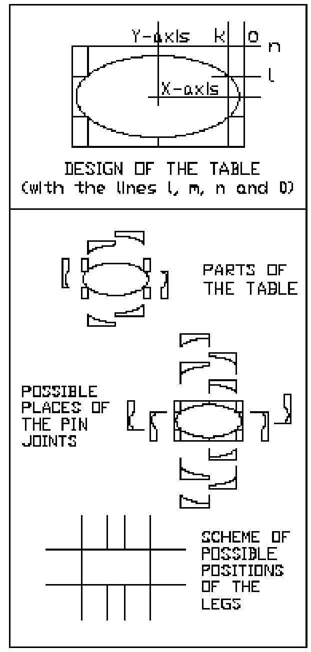

Figure 2.1:*Design and leg positions*

Leg positions. There are 6 possible legs and each leg has two possible places for the pin joints (figure 2.1). To determine what combinations of leg positions are possible, I constructed the matrix ***M*** from the product of the vector of possible numbers of legs on the short side ***S*** and the vector of those on the long side of the table ***L***. The content of the vectors is exposed in figure 2.2 and the matrix is shown in figure 2.3. Using the matrix ***M***, I made a cross table to show the possible combinations of leg positions.

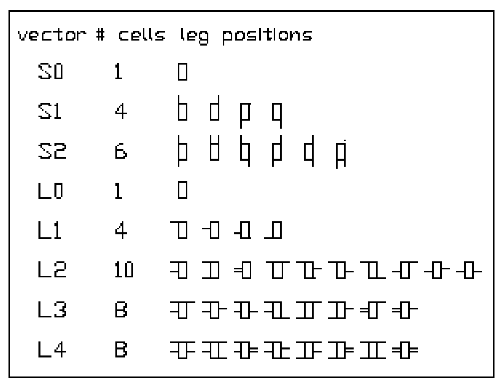

Figure 2.2: *Exposure of the vectors.*

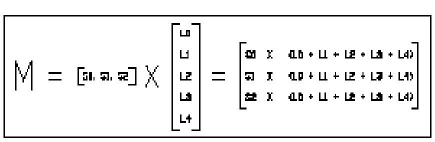

Figure 2.3: *Matrix M.*

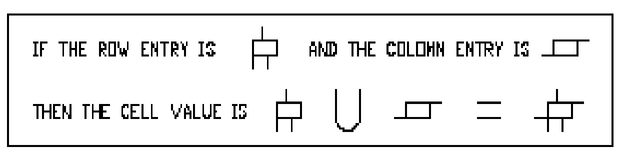

Figure 2.4: C*alculation of the cell values.*

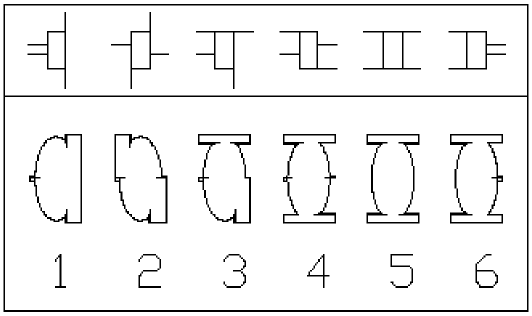

Figure 2.5: *Final selection of tables.*

Figure 2.6: *Model 1*

Figure 2.7: *Model 2.*

Figure 2.8: *Model 5.*

In the cross table I excluded entries in the L-vectors that in combination with the S-vectors would produce mirror images. Figure 2.4 shows how the cell values in the cross table were determined. The cross table has 11 rows and 31 columns, so in total 341 cell values. The whole includes cases with 0, 1, 2, 3, 4, 5, or 6 legs, including a number of mirror images**.**
The cross table will be shown and explained in Figure **PP**.

Selection. To select which tables to make, I used the criteria of stability, ease of construction, and beauty. While the table with 0 legs is very stable and can be used as a picnic table, I excluded

the cases with 1, 2 and 3 legs and some with 4 and 5 legs (176 cases).When a leg on the short side and one on the long side come together, the result is unworkable because the rectangle with the pin joints comes loose by cutting (Figure **PP**). Hence these were also excluded (80 cases).
Then I excluded the remaining mirror images (10 cases). There were now 75 cases left.
The most complicated criterion was "beauty" because it is a personal perception. Finally, I was left with 6 tables that I thought were worth constructing (figure 2.5) and prototypes were made of the first, second, and fifth. (see figures 2.6 to 2.8).