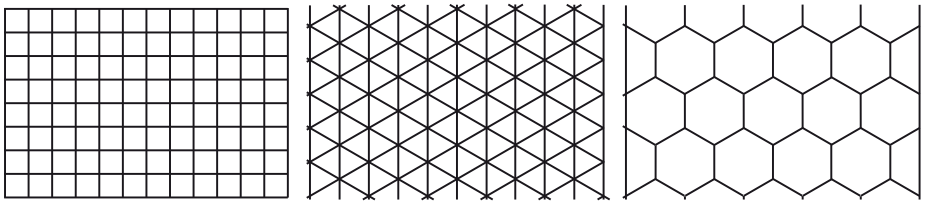
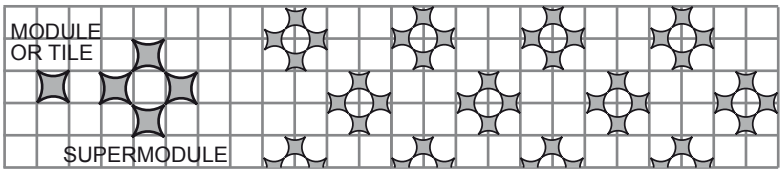
Modular grids: are generally geometric structures in which a figure is repeated to form a composition. These figures are usually polygons or equivalent shapes.
Modular grids composed of figures that fill in the plane without gaps are called tessellations. There are only three regular tessellations (made repeating regular polygons).



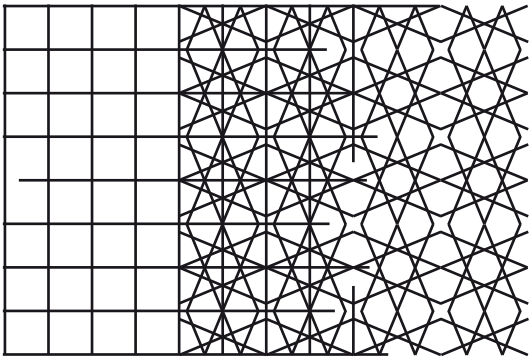
The module or tile is the basic figure which is repeated in the compositions of Modular grids. As shown in the drawings on the left, there are only three regular polygons that tessellate the plane, the Regular grids.

The super-module or main module is a figure composed of several basic modules which also acts as a module in a composition.



The Arabs were specialists in developing this type of decoration. In Muslim culture, because of the doctrines of the Koran, the artists and craftsmen must not represent human figures or animals in temples, religious objects or books. That is why they chose this way of decoration, in which modules are not recognizable figures of people or animals.

But Muslim culture is not the only one who has developed the partition of the plane. Mathematicians, artists and designers have also approached to study this interesting fact. Escher or Vassarelly are two very good examples.



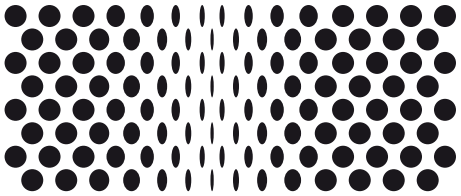
Simple Modular Network | Composite Modular Network | Simple polygon Network

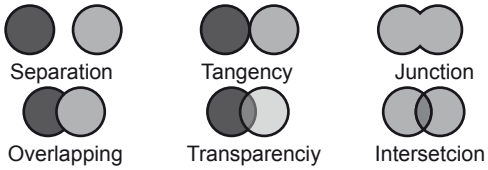
Simple Modular grids: are composed of one single figure repeated.

Composite Modular grids: Are those consisting of two or more figures that repeat. When these figures are tilings must be polygons, even if they have different number of sides they must have equal sides.

There are also modules or Modular grids composed of overlapping networks or simple tiles.

The anomaly is a plastic resource that changes the order, the position or shape of the tiles or units to attract attention creating motion effects, or three-dimensional plane distortion. Bridget Riley and other artists of the Op Art were experts applying this visual appeal.



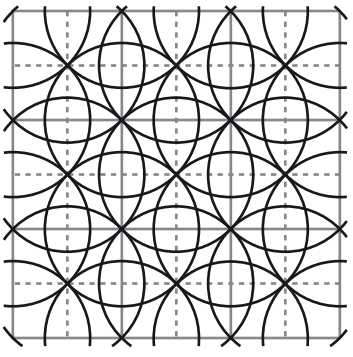


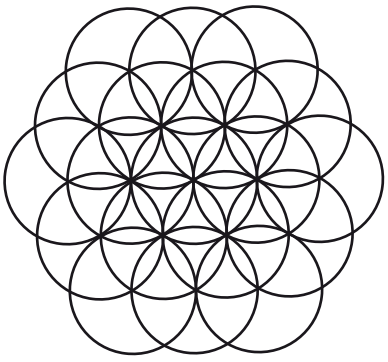
The circles are also very common in grids. But as they do not show sides in their outlines can not fill the plane in a tessellation. On the left, the ways in which the circles can be arranged to accomplish pattern compositions with them as tiles.

On the right we see two different ways to arrange the circles on the plane.

These two forms were the basis that Muslims used to from them, linking different intersections getting semiregular tessellations.

A semi-regular tessellation is one that with regular polygons (all with the same side length) while filling the plane leaving no gaps.

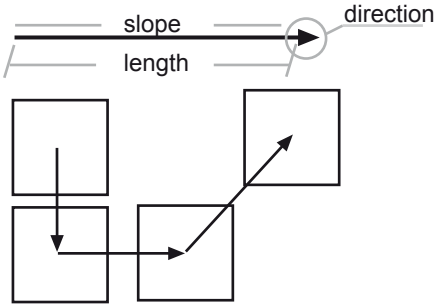


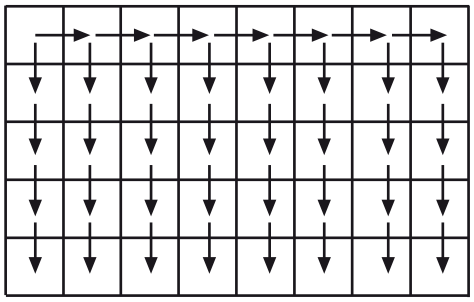


Movements in a plane:Dynamic Geometry: Isometries

A movement is transforming the position of a figure in the plane, in this case our modules or tiles. Specifically, when we apply a movement, the tile will hold its shape (its sides, its size, its area and its angles are equal: Isometry) but change its position in the plane. There are three types of Isometric movements:

TRANSLATION:

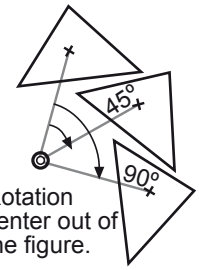




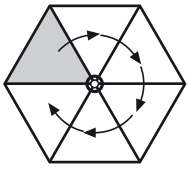
Translate a figure is moving it, pushing it. All translations are determined by a vector. A vector is determined by a lenght (modulus or distance), a slope and a direction

ROTATION OR TURN

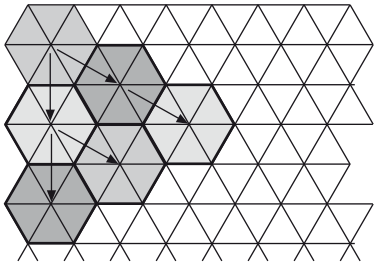
To rotate a figure you need a center of rotation, an angular length and a direction (clockwise or counterclockwise). The rotation center may be positioned inside or outside the edges of the figure



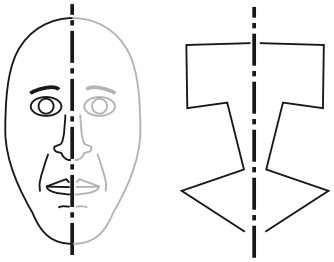
Rotation center out of the figure.



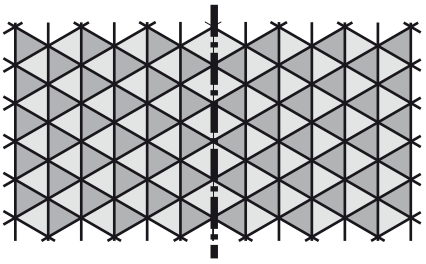
Rotation center on a vertex of the figure. 5 times repeated 60 degrees rotation.



AXIAL SYMMETRY OR REFLEXION



Symmetry is a geometric transformation operation or which is present in many natural and artificial objects. It consists of reflecting the figure regarding an axis of symmetry. All symmetrical points are on a perpendicular to the axis, across and at the same distance of it.

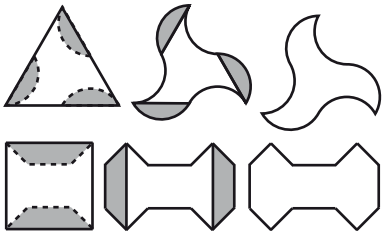


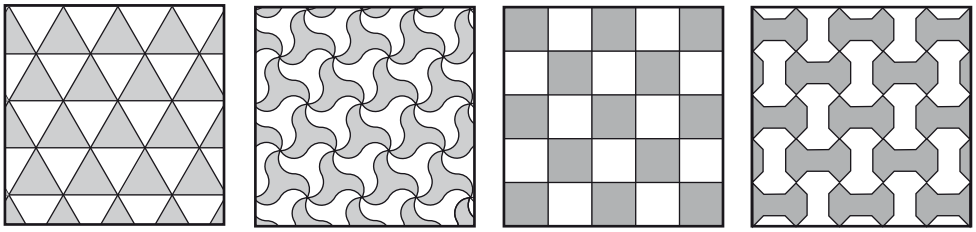
Tile transformations in tessellations: EQUIVALENCES

We have seen that there are three regular tessellations (triangles, squares and hexagons) and semiregular (there are eight), in which more than one regular polygon appear. We can also find many tessellations whose tiles are irregular polygons. And being repeated they can fill the plane (irregular triangles, rhombuses or rectangles for example).

There is the possibility of altering the shape of the tile (mainly used in tessellations that only one tile, figure or module) so that the altered shape fill in the same way the plane. These employ equivalent figures .

The equivalence is a ratio between figures (any plane figure) where the original shape and the transformed have the same surface area.





As we can see in the pictures above we have obtained an equivalent figure of the triangle (called Nazari birdie) and another figure (Nazari bone) equivalent to the square. We got the new figures cutting and pasting the cuts in a different places.

These cuttings or transformations atend to the laws of isometries (translation, rotation and symmetries). There are various procedures methods to obtain an equivalent figure, applying isometries, also tessellating the plane as the original figures. The Arabs and M.C. Escher were experts on this topic.