

# Beginner Geometric Construction

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## 1 Introduction

The focus for this class is on creating geometric patterns while using only a straight edge and a compass.

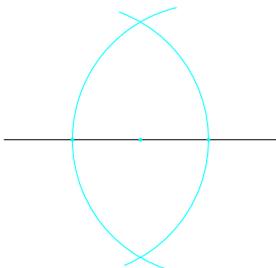
### 1.0.1 Supply List

- a compass, preferably one which uses a screw to adjust the radius
- a straight edge
- a pencil and a good eraser
- a pen to outline the final design
- paper to draw on
- a pad or similar to place under the paper.

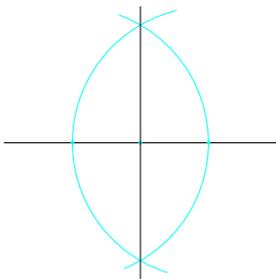
Generally, after drawing the figure in pencil, I will trace over the lines I actually want to keep with pen, then erase the pencil marks, and finally colour the figure.

*Accuracy is important!* When you first start practising, make your shapes bigger so you can see the relevant points more easily. Mark the centres of the circles you draw, so you can find them again.

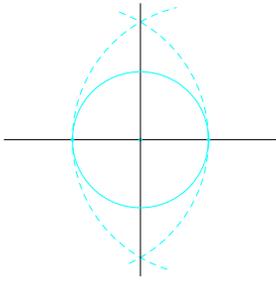
## 2 Drawing a Square



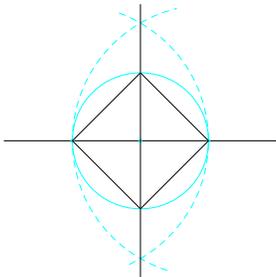
- Draw a straight line. Mark a spot at the center (approximate) of the line.
- Use the compass to make two spots equally distant from the center.
- From these two points draw two arcs with equal diameter, that meet above and below the straight line. (See the solid blue line)



- Connect the points of intersection above and below the original straight line with a straight line.

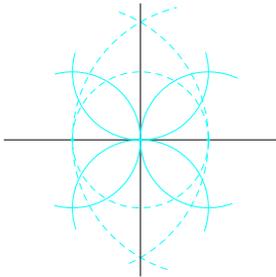


- Draw a circle at the intersection of the two straight lines, with radius equal to the distance from the center to either of the points used in the first step.

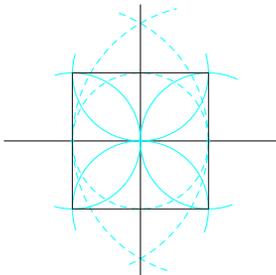


- Connect the four points where the circle meets the straight lines to get a *dynamic*<sup>a</sup> square.

<sup>a</sup>A dynamic square is one that's shown with a point bottom most, rather than a horizontal line.



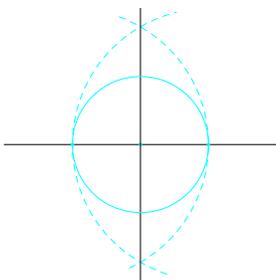
- Instead of drawing the dynamic square, draw four arcs, each centered at one of the places where the circle and the straight lines cross, with the same radius as the circle. Each arc should be slightly more than half a circle.



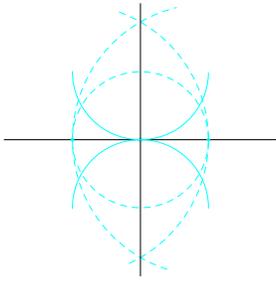
- Draw straight lines connecting the four points where the arcs cross. - Notice how the arcs inside the square can be used as a simple geometric pattern.

### 3 Drawing a Six Pointed Star (or a hexagon)

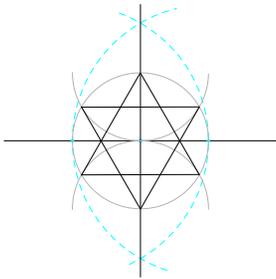
Starting with the same setup as we did for the square, we can draw a hexagonal star.



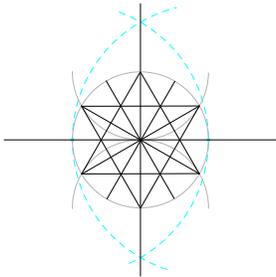
- Repeat the first steps from drawing a star until you reach this point. - Draw a circle at the intersection of the two straight lines, with radius equal to the distance from the center to either of the points used in the first step.



- Draw two arcs centered at the points where the vertical line crosses the circle, with radius equal to that of the circle.



- Connect four the points where the arcs cross the circle in horizontal lines.  
 - Connect each of the four points to the point where the circle meets the vertical line on the opposite side of the circle.



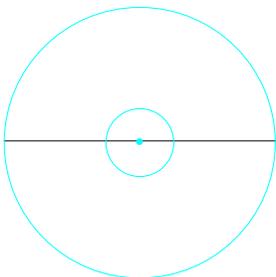
- We can add extra lines to make the shape more interesting than a simple hexagon by, for instance adding lines connecting the points of the hexagon, as well as the points where sides meet.

## 4 Drawing the Compass Rose

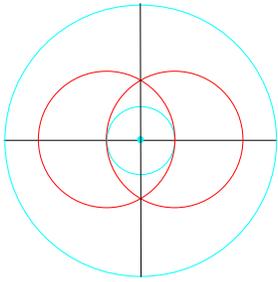
The 16 point compass rose is drawn with compass and straight-edge. In the diagrams red and sometimes green edges are used to indicate the current step. Black edges will be a part of the final figure.

Note that the four *cardinal* directions on a compass are North, East, South and West. The *ordinal* directions bisect the cardinal directions and are the northeast, southeast, southwest, and northwest.

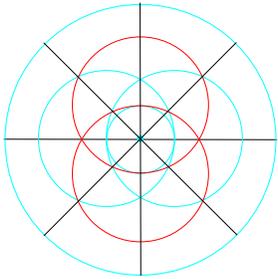
If you draw a large compass rose, it is possible to go past 16 points – i have drawn up to 64 in the past – but it all gets very very fiddly. With a lrg inner circle, 8 points can be sufficient.



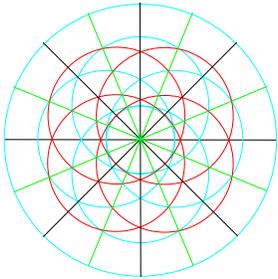
- Draw a straight line.  
 - Mark a point in the center of the line. Draw two circles, both with the same center. The outer circle will determine the size of your compass rose; the inner circle will determine how stubby or slender the compass points are.



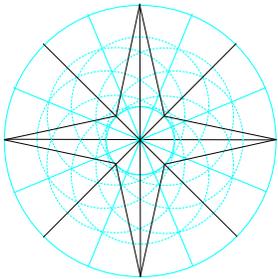
- Set your compass to the diameter of the inner circle. We will draw all the helper circles with the same diameter.
- The first two helper circles are centered where the inner circle meets the horizontal line.



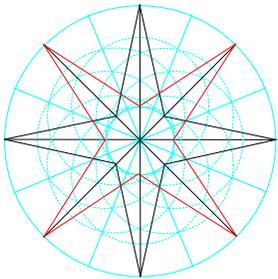
- The next two helper circles are centered where the inner circle meets the vertical line.
- Draw the two straight lines; both pass through the center and points where the helper circles intersect.



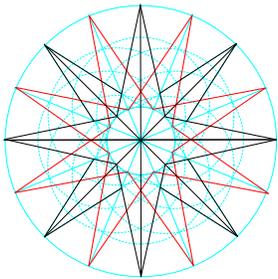
- The four red circles are centered on the four points of intersection between the inner circle and the two straight lines drawn in the previous step.
- Use the intersections between the new (red) and existing (light blue) circles to draw the light green lines, each of which passes through the center and two opposing points of intersections.
- At this point the only circles we will need are the inner and outer circle. But don't erase anything yet; it's too easy to erase too much.



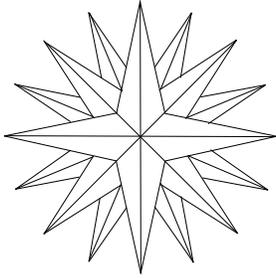
- Using your pen, redraw the cardinal straight lines. Also draw the ordinal straight lines show in the picture.
- Draw straight lines from the endpoints of the cardinal lines to the points where the ordinal lines meet the inner circle.



- The lines that we add for the ordinal points lie on the line from the end point to the place where the cardinal line meets the inner circle, as shown by the red line.
- However, when drawing the lines from ordinal point to cardinal intersection, stop at the point where the line intercepts previously inked lines.



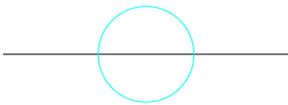
- The eight remaining points are drawn similarly, being careful not to ink too far.



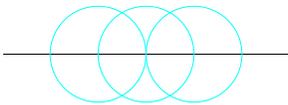
- Erase all the pencil marks, and what remains is a compass rose.

## 5 Drawing a six lobed flower

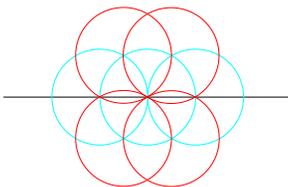
The six lobed flower is the first example of a figure where we draw arcs to connect circles of various diameters.



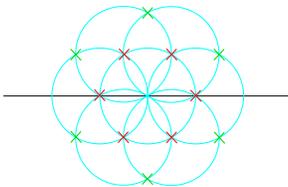
- Draw a straightline, and a circle whose centre lies on the line. Your final figure will be twice as wide as this. Note that you will be drawing a number of circles of the same radius.



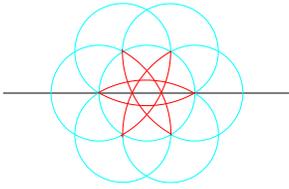
- Draw two circles centered at the two points where the first circle intersects the straight line.



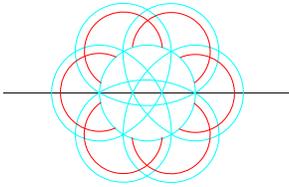
- Draw four more circles; the center for each circle is one of the four points where the two circles from the previous step intersect the first circle.



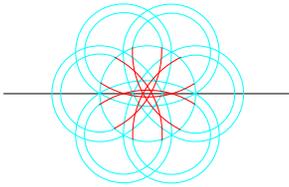
- This picture is for information purposes only. The red crosses are the centers of the six circles. The green crosses will be the centers of circles whose arcs travel through the middle.



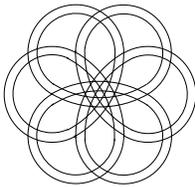
- Erase everything inside the first circle.
- Measure the radius for the new circles from the topmost green cross to where the inner circle intersects the horizontal line.
- Draw six arcs, centered on the six green crosses; shown in the figure here as red lines.



- Now to turn the lines into ribbons ...
- From the red crosses want to make circles that are slightly smaller. Usually you can gauge that by eyeballing it.



- Next draw the inner arcs centered on the green crosses.



- Outline the edges, and possibly interlace the ribbons, and then erase the helper circle and straight line.