Designing a Sundial with Period Techniques

An Introduction to Geometric Construction as a Medieval Tool

Master Richard Wymarc
mka:
Timothy J Mitchell

Acknowledgements

This is a handout for my class "Designing a Sundial with Period Techniques" first given at Pennsic University 2025

Copies of this handout are available on my website at www.astrolabeproject.com

Version 1 – July 2025

Types of Sundials
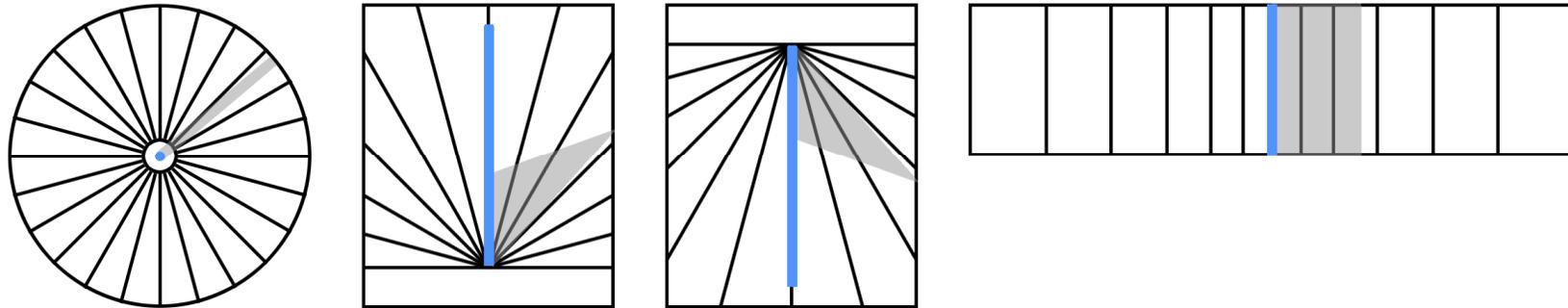
There is a wide range of types and designs of sundials, ranging from the functional and basic, to the ornate. But here we will be looking at four of the most common designs:

- Equatorial
    - Circular, with the gnomon being a perpendicular rod in the center. The simplest sundial.
- Horizontal
    - The most familiar type. It lays flat, oriented north with a gnomon at an angle equal to the latitude
- Vertical
    - Similar to the horizontal dial, it is placed vertical, facing south with the gnomon at an angle equal to 90 degrees minus the latitude
- Polar
    - A polar sundial is oriented so that it faces south and is tipped to an angle equal to the local latitude. The gnomon, is a blade perpendicular to the face of the dial.

Except for the equatorial sundial, these all require their hour lines to be laid out based on the current latitude. For example, determining the proper hour angles for just the horizontal sundial is given by this equation:

$$H = tan^{-1}(\tan T \sin L)$$

Where H is the angle of the hour line, T is the hour angle, and L is the latitude.
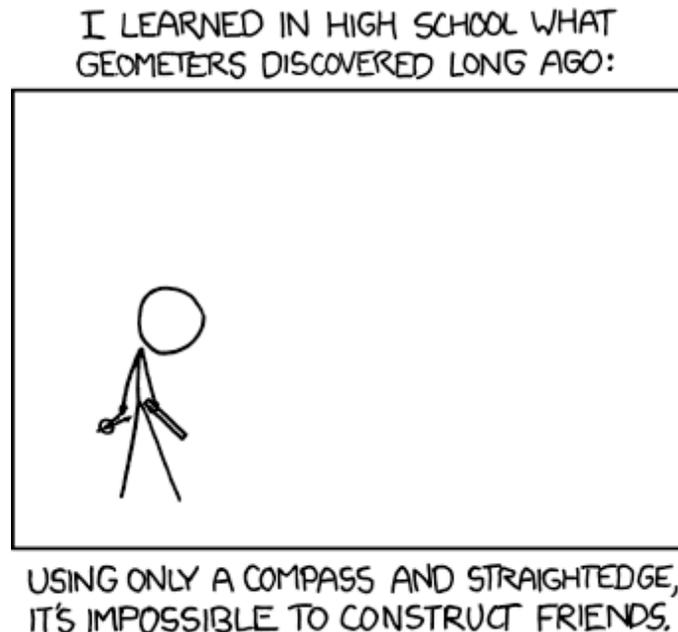
OR

All four sundial faces can be laid out at the same time using a straight edge and compass using Geometric Construction.

Geometric Construction

Geometric Construction: Constructing designs using only straightedge and compass.

Geometric construction is a fascinating discipline that explores the art of creating precise and intricate designs using only a compass and a straightedge. Dating back to ancient times, this methodical approach to construction has played a crucial role in fields such as art, architecture, engineering, and mathematics. Through a series of carefully executed steps, geometric construction allows us to construct various shapes, lines, and angles with unparalleled accuracy. Whether it's constructing perpendicular lines, bisecting angles, or inscribing polygons within circles, the principles of geometric construction provide a solid foundation for problem-solving and understanding the intricacies of geometry.

Many, if not all of you will have been exposed to geometric construction in high school but let us review the basics.
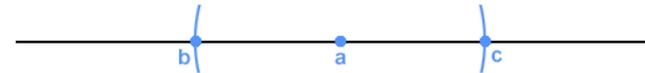
I LEARNED IN HIGH SCHOOL WHAT
GEOMETERS DISCOVERED LONG AGO:

USING ONLY A COMPASS AND STRAIGHTEDGE,
IT'S IMPOSSIBLE TO CONSTRUCT FRIENDS.

Relevant XKCD
(There is always a relevant XKCD)

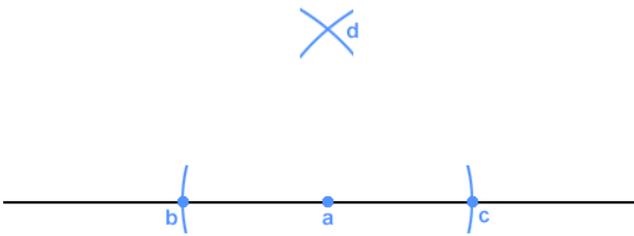# The Basics of Geometric Construction

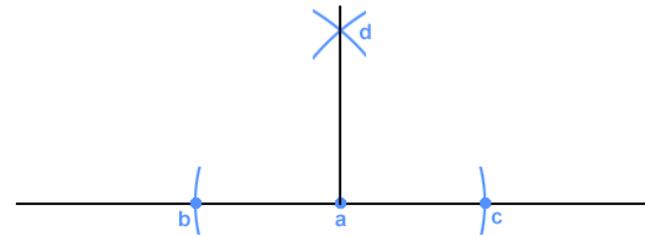- Erecting a perpendicular from a point on a line

Step 1: Pick the point where you want the perpendicular line 'a'

Step 2: Place the compass point on 'a' and draw two arcs as shown, marking points b and c

Step 3: Open up the compass a bit, and place the compass point on points b and c in turn, drawing two intersecting arcs as shown, marking points d and e

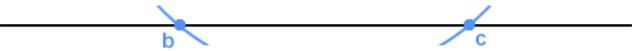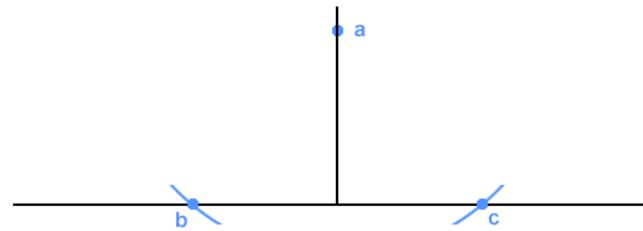Step 4: Place your straightedge on points d and e and draw a line from a to d

The Basics of Geometric Construction
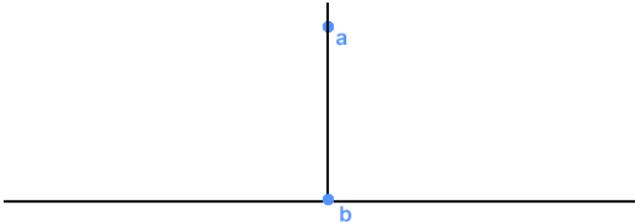
- Dropping a perpendicular from a point to a line

• a

Given a point 'a' draw a line from it perpendicular to the given line.

• a

Step 1: Place the compass point on 'a' and draw two arcs as shown, marking points b and c.

• a

b   c

d

Step 2: Place the compass point on points b and c in turn, drawing intersecting arcs as shown, marking point d.

• a

b   c

d

Step 3: Place your straightedge on points a and d and draw a line from a to d

The Basics of Geometric Construction

- Drawing a parallel line through a point

Given a point 'a' and a line, draw a line passing through 'a', parallel to the given line.

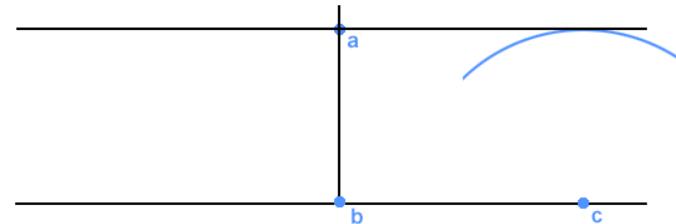Step 1: Drop a perpendicular line as shown previously.

Step 2: Place the compass point on point b and open it to touch point a. then place the compass point on the line at an arbitrary point and draw an arc as shown.

Step 3: Place your straightedge on point a and the arc and draw a line.

Note: If you already know the desired distance between the parallel lines, you can skip Step 1 and just use two arcs in Step 2.
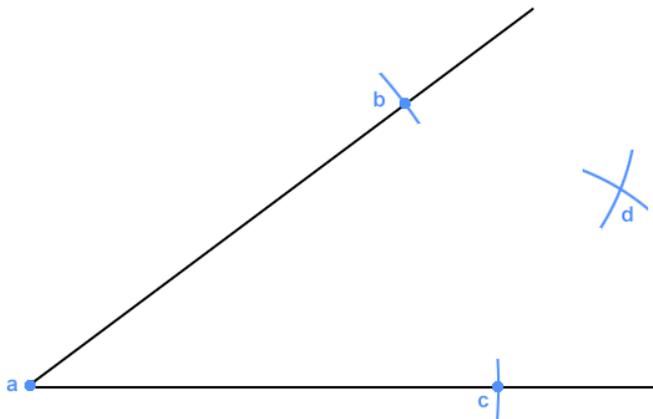
The Basics of Geometric Construction
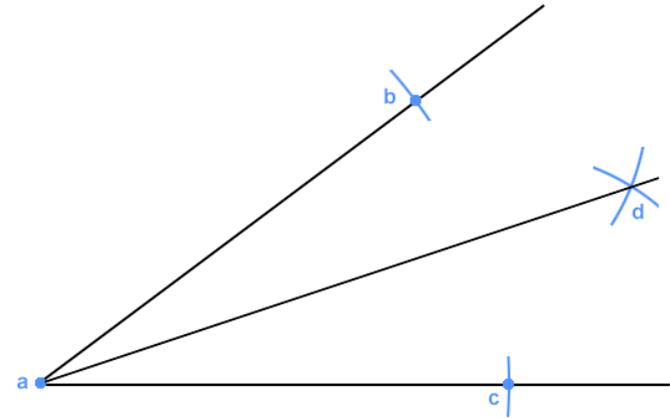
- Bisecting an angle
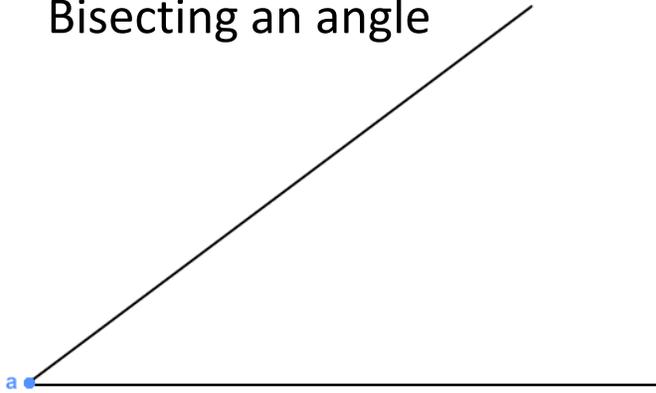
Given two lines intersecting at an angle point 'a' draw a third line that bisects the angle.
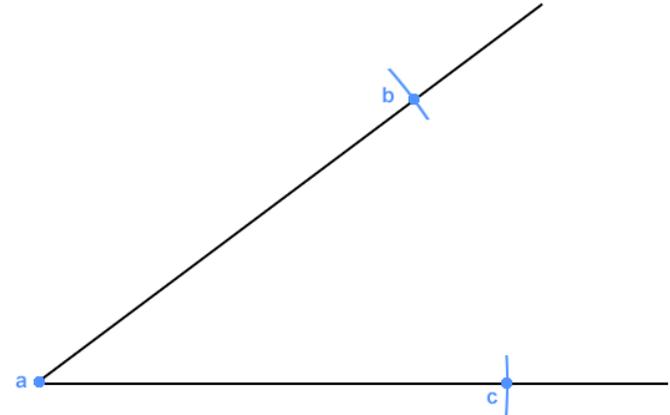
Step 1: Place the compass point on 'a' and draw two arcs as shown, marking points b and c.
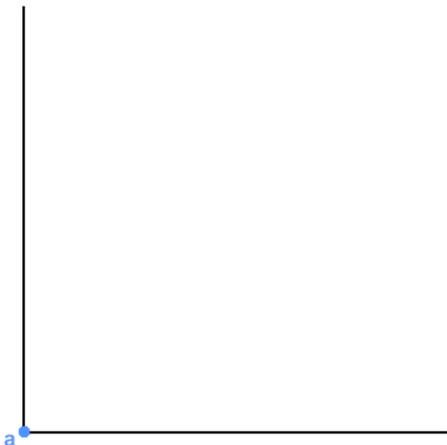
Step 2: Place the compass point on points b and c in turn, drawing intersecting arcs as shown, marking point d.
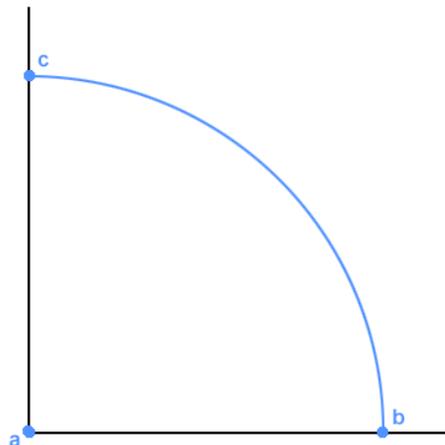
Step 3: Place your straightedge on points a and d and draw a line from a to d

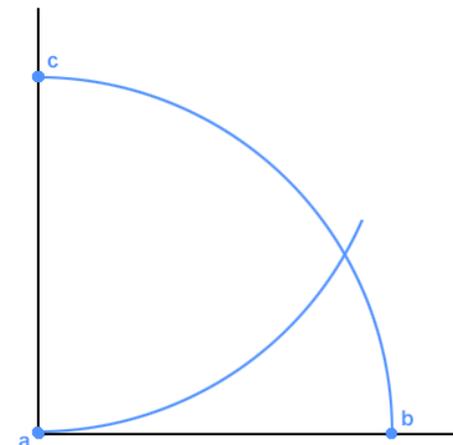# The Basics of Geometric Construction
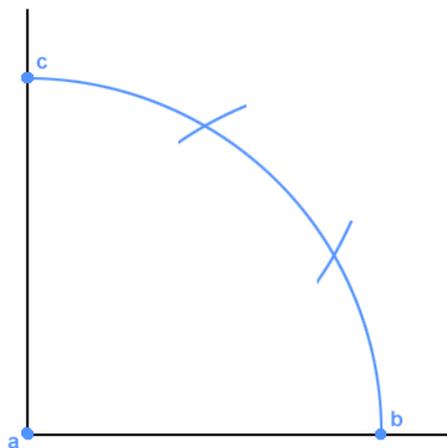
- Trisecting a 90-degree angle

Given two lines intersecting at a 90°
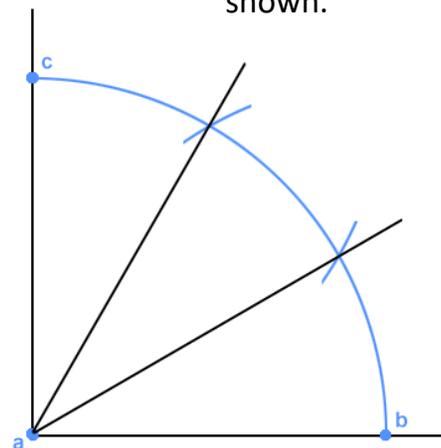angle point 'a', draw two lines
trisecting the angle.

Step 1: Place the compass
point on 'a' and draw an arc
as shown, marking points b
and c.

Step 2: Keeping the compass at the
same setting, place the compass
point on point c and draw an arc as
shown.

Step 3: Repeat with point b

Step 4: Draw lines from point 'a'
to the intersections.

Class Notes

The process we will be using is taken from Hartmann's *Practika* (1528) and Oronce Finé's *First Book of Solar Horology* (1560).

We are going to do this workbook style: The handout will explain each step, the worksheets will give you a chance to practice each step, and the next worksheet will start with a cleaned-up version of the figure you just completed.

Take your time. Try to be as accurate as possible. It isn't necessary to do all the parts of a given worksheet, bisecting 12 angles, for example, will get tedious. Do enough to understand what you are doing

Concerning accuracy:

Technique is a very important part of getting an accurate result. The more care you put in, the better the finished design. To that point some pointers:

- The larger the drawing, the more accurate it will be.
- Pencil points have a radius. Use a sharp pencil, place the pencil, THEN the straightedge, then draw the line.
- When using the compass to draw intersections, try to make the intersections meet at right angles, this defines the intersection point much better.
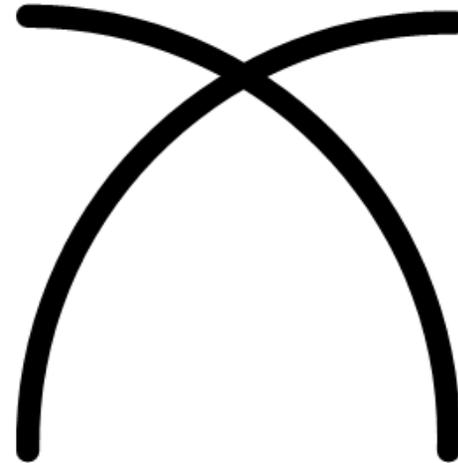
Part One: Determining the Three Radii

We will be making four sundial faces.
- Equatorial
- Horizontal
- Vertical
- Polar

The first three dials are circular. Their relative radii depend on the latitude that the sundials will be used at. For the equatorial dial, the latitude does not matter, but for the last three dials, the angles between the lines will vary depending on the latitude. We will use the equatorial dial, where the lines are equally spaced, to construct the rest.
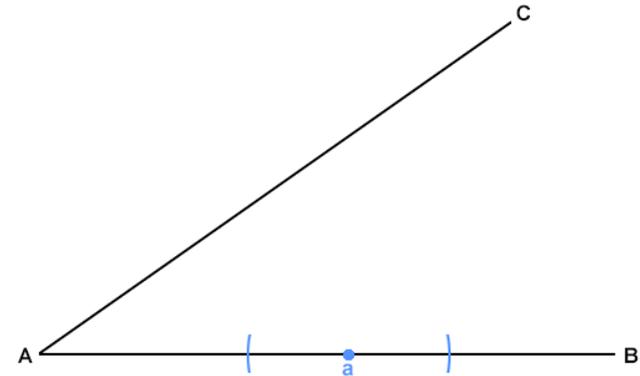
To do this we first need to determine the relative radii of the three circular dials.

First Figure - Getting the Radii

First, we need to determine the relative radii for our sundials based on the latitude
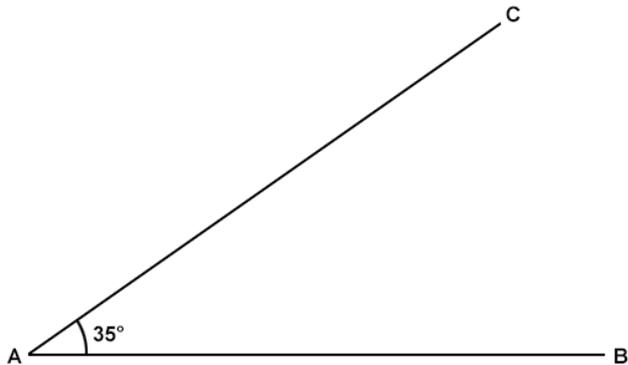
1. Draw a Horizonal line AB, then a second line AC, making an angle equal to your latitude (we are using 35 degrees here.

2. Select a point 'a' where you want your vertical line and place the compass point on it. Draw two arcs on the horizonal line to mark points b and c.
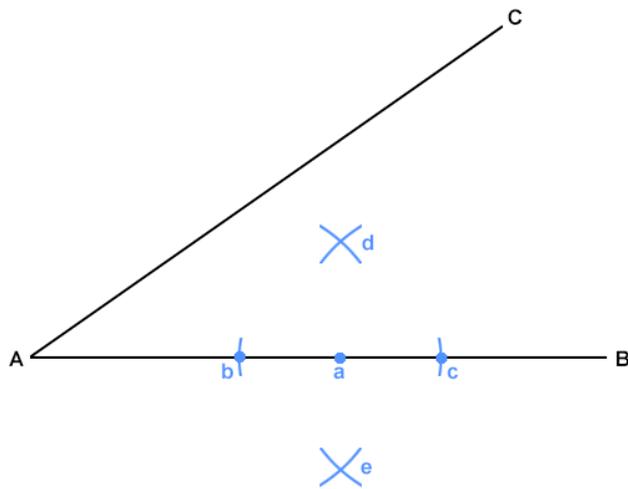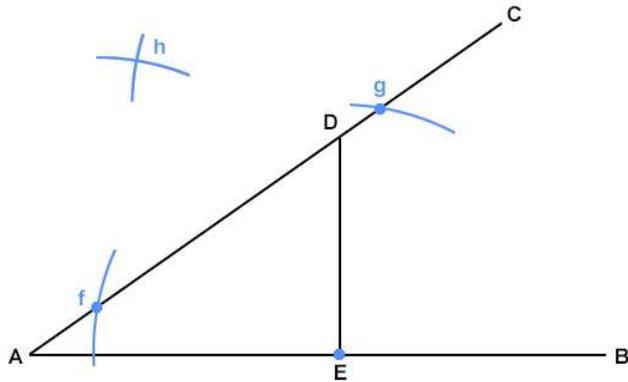

3. Open the compass slightly and place the compass point on points b and c in turn. Draw the intersecting arcs d and e as shown.
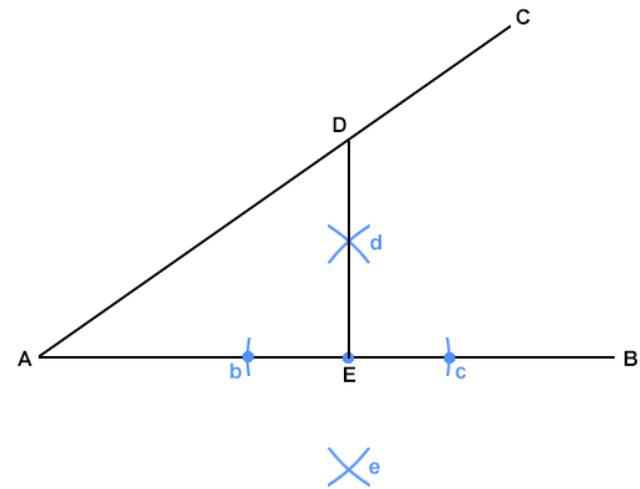
4. Using the straight edge, draw a line DE between d and e from the line AB to line AC.
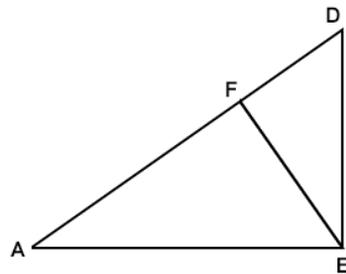
First Figure - Getting the Radii

5. Place the compass point at E, then draw two arcs as shown to mark points f and g on line AC.

6. Place the compass point on f and g in turn drawing an intersection at h.
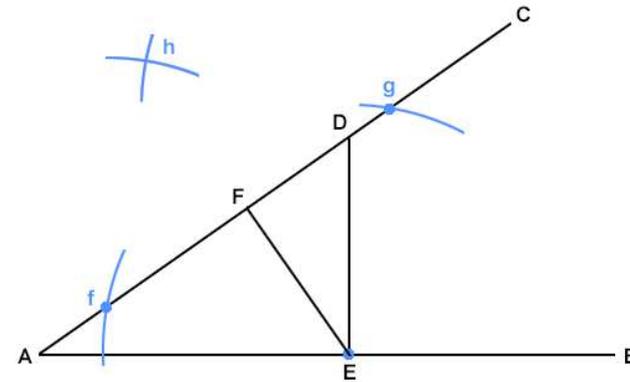
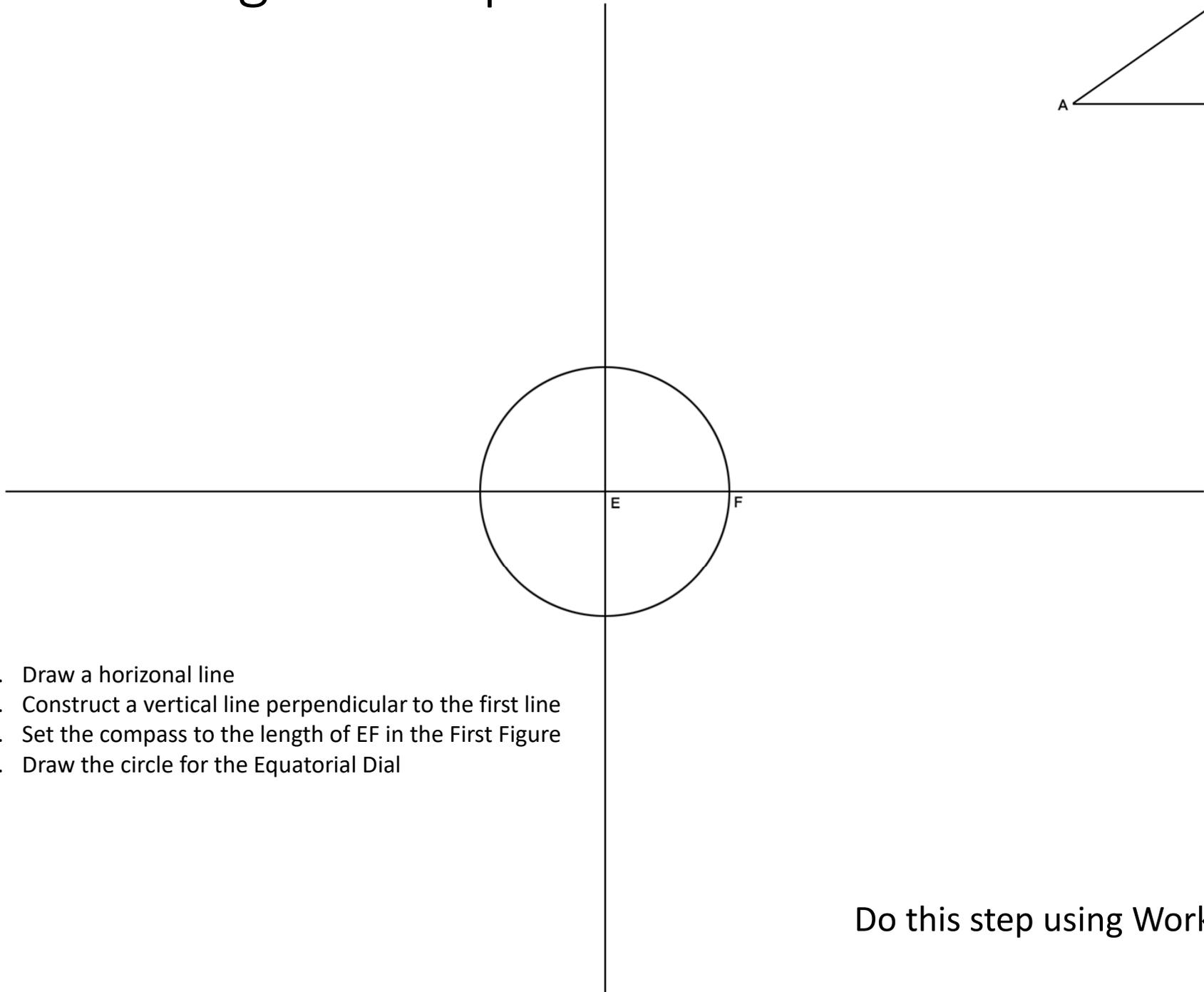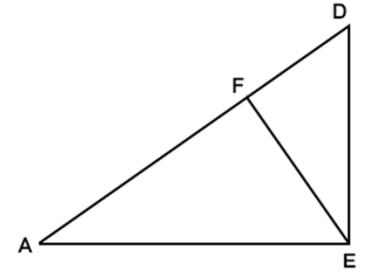7. Using the straight edge, draw a line from E to h to make line EF as shown.

Clean up the figure as shown.

EF is the radius of the Equatorial Dial
AE is the radius of the Horizontal Dial
DE is the radius of the Vertical Dial

These radii will be transferred using the compass to the next figure.

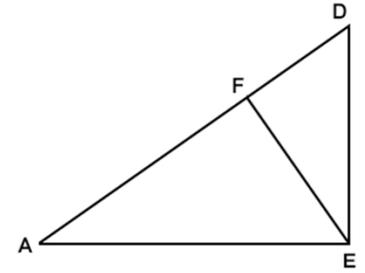Now construct the First Figure using Worksheet 1

Second Figure: Step 1

1. Draw a horizonal line
2. Construct a vertical line perpendicular to the first line
3. Set the compass to the length of EF in the First Figure
4. Draw the circle for the Equatorial Dial
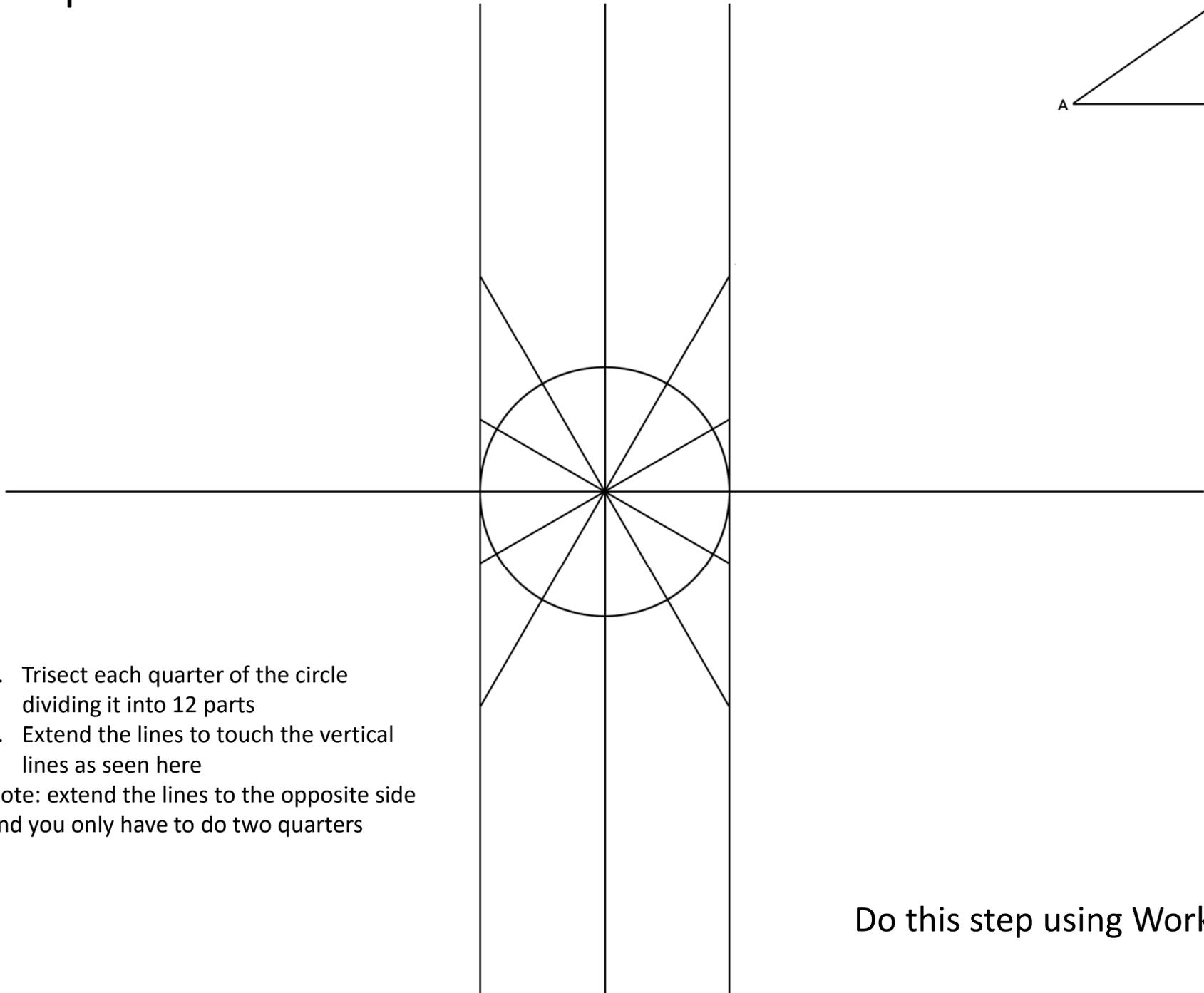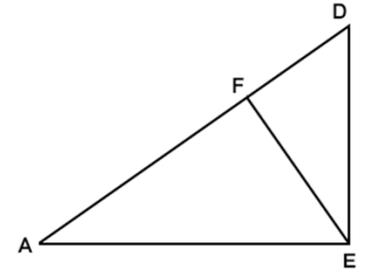
Do this step using Worksheet 2

Step 2
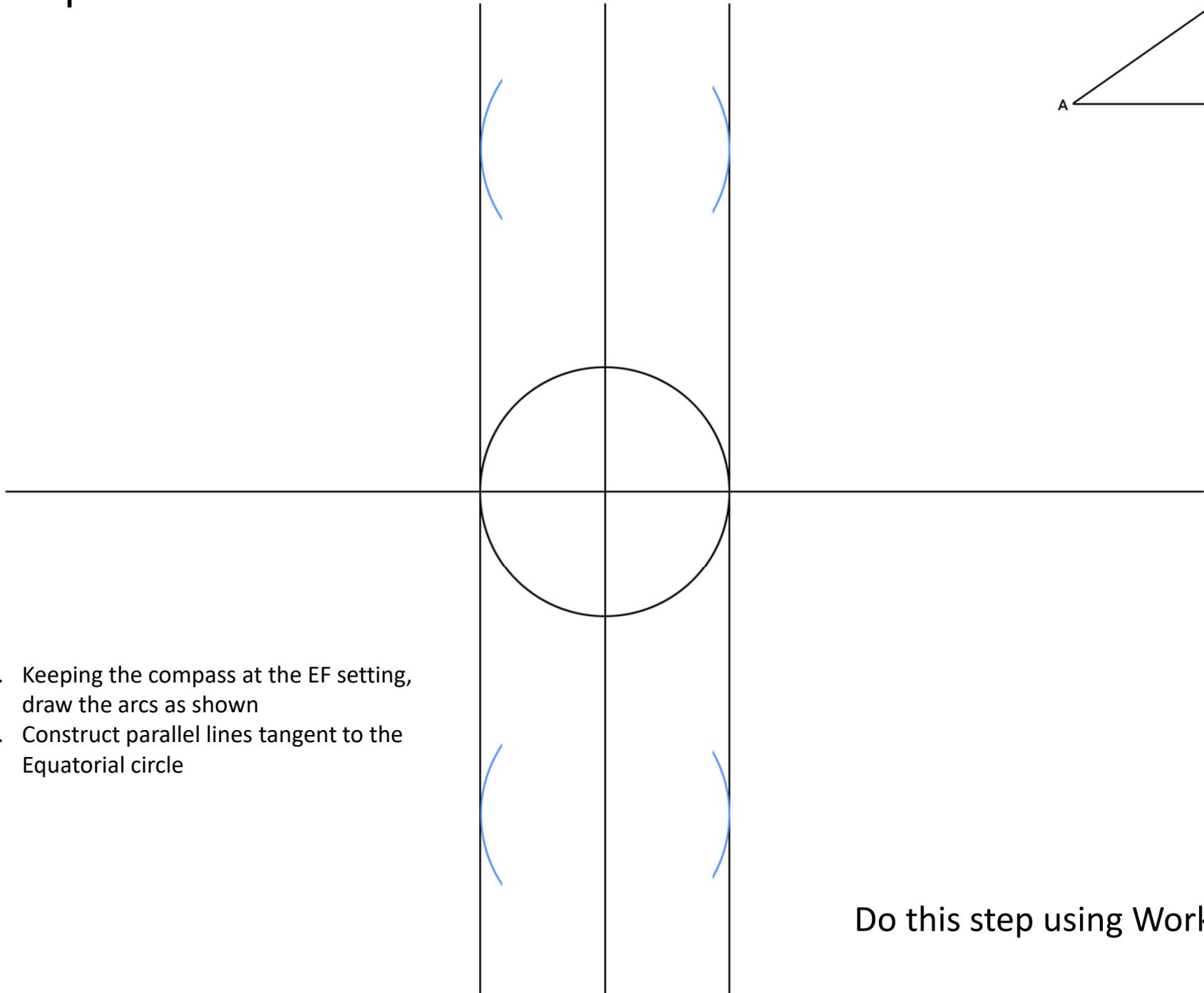
1. Keeping the compass at the EF setting, draw the arcs as shown
2. Construct parallel lines tangent to the Equatorial circle
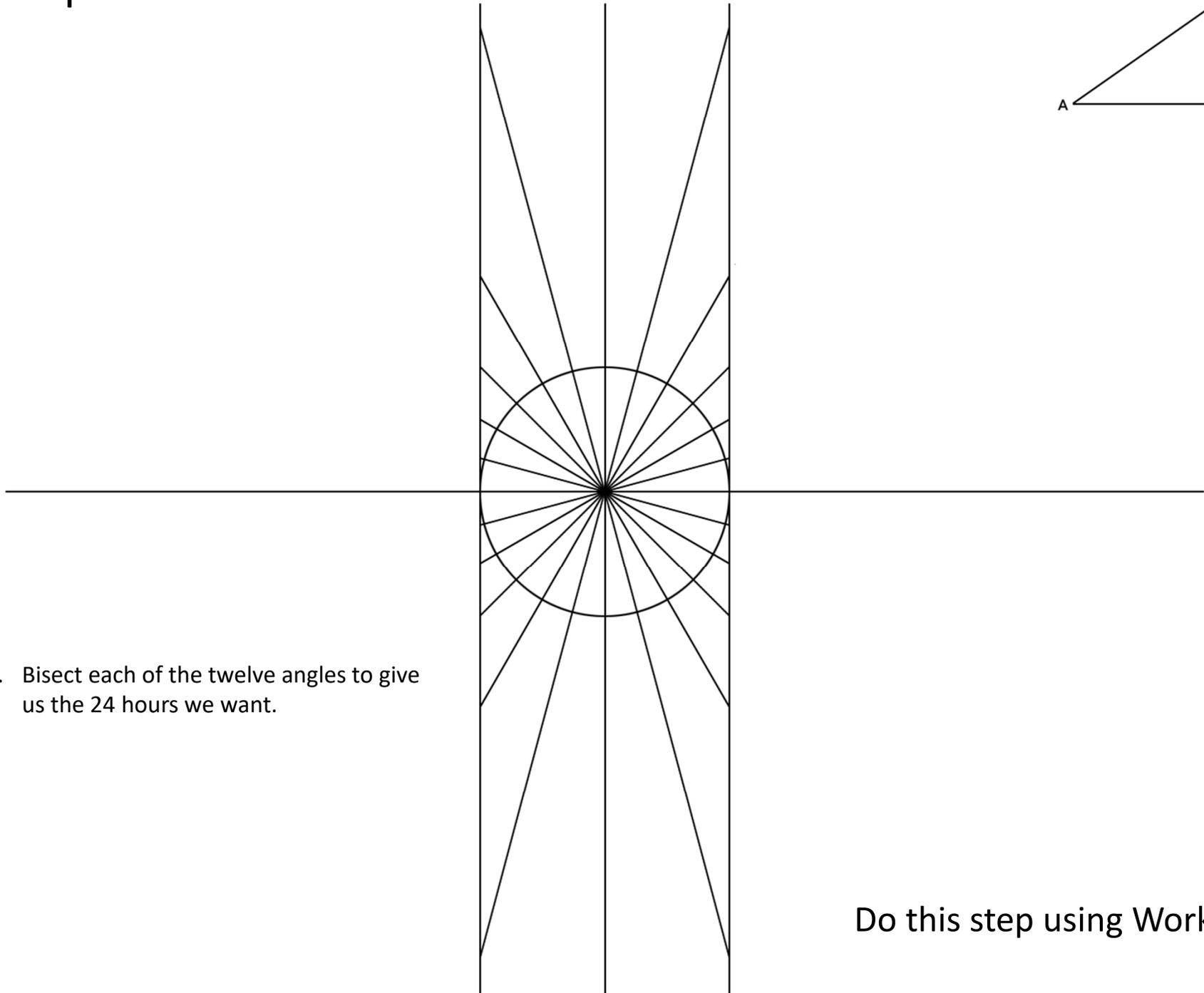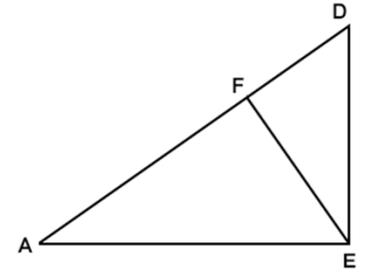
Do this step using Worksheet 2

Step 3

1. Trisect each quarter of the circle dividing it into 12 parts
2. Extend the lines to touch the vertical lines as seen here

Note: extend the lines to the opposite side and you only have to do two quarters
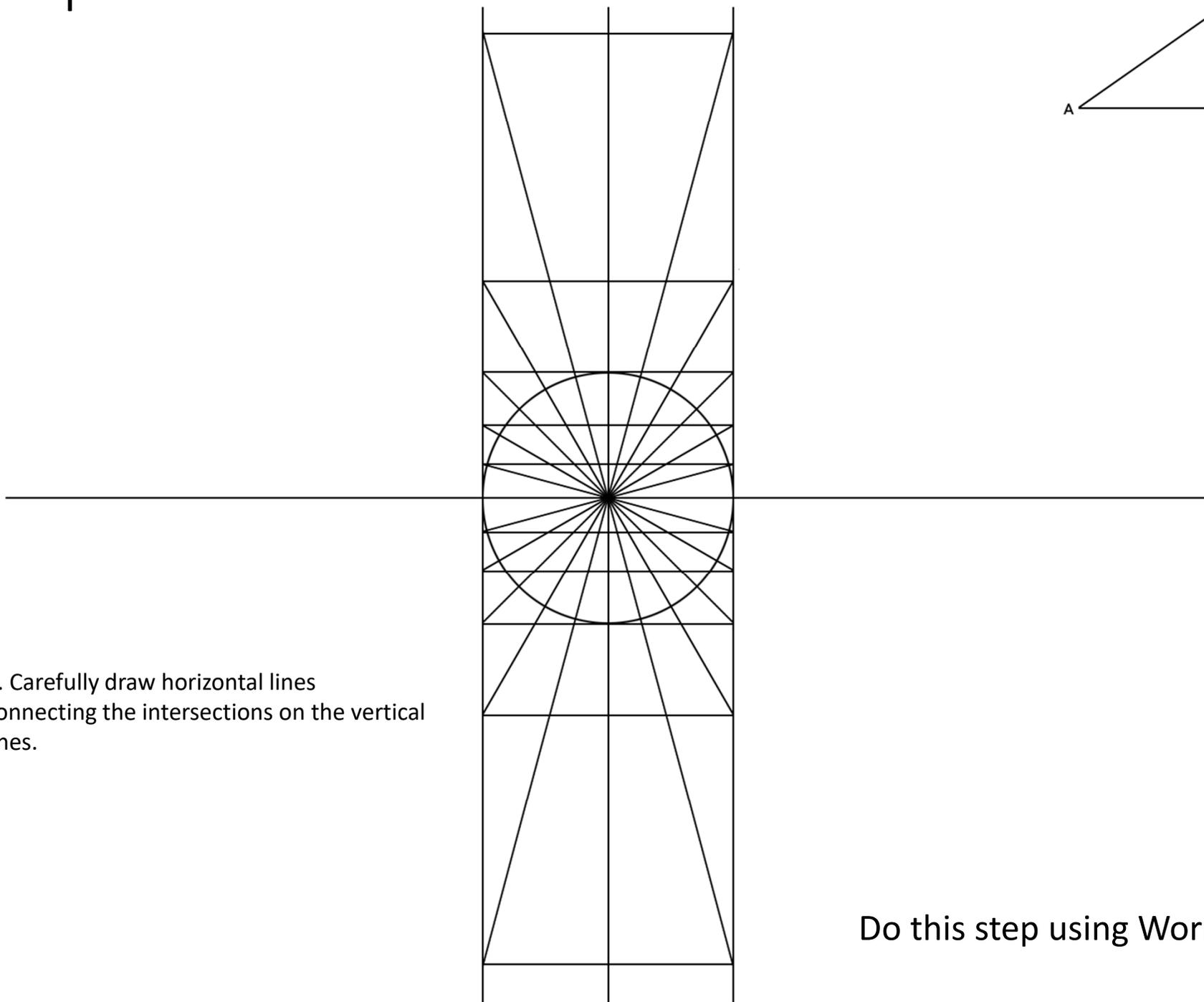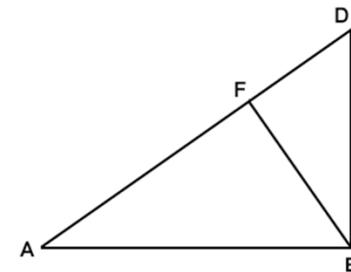
Do this step using Worksheet 3

Step 4

1. Bisect each of the twelve angles to give us the 24 hours we want.
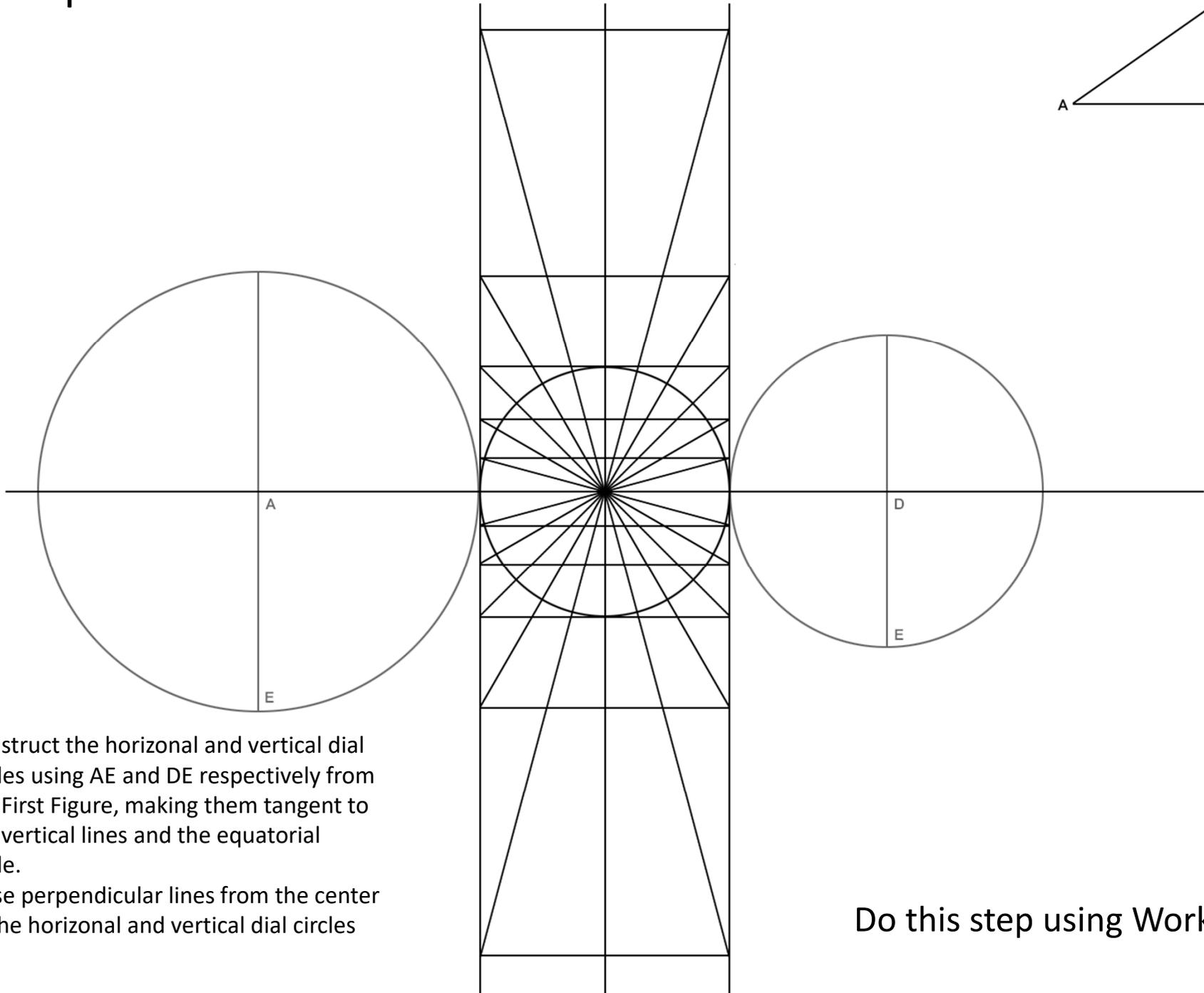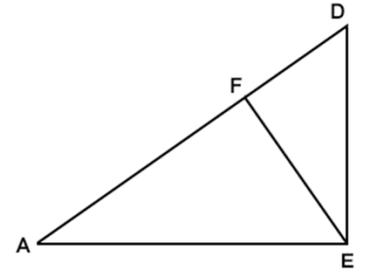
Do this step using Worksheet 4

17

Step 5

1. Carefully draw horizontal lines connecting the intersections on the vertical lines.
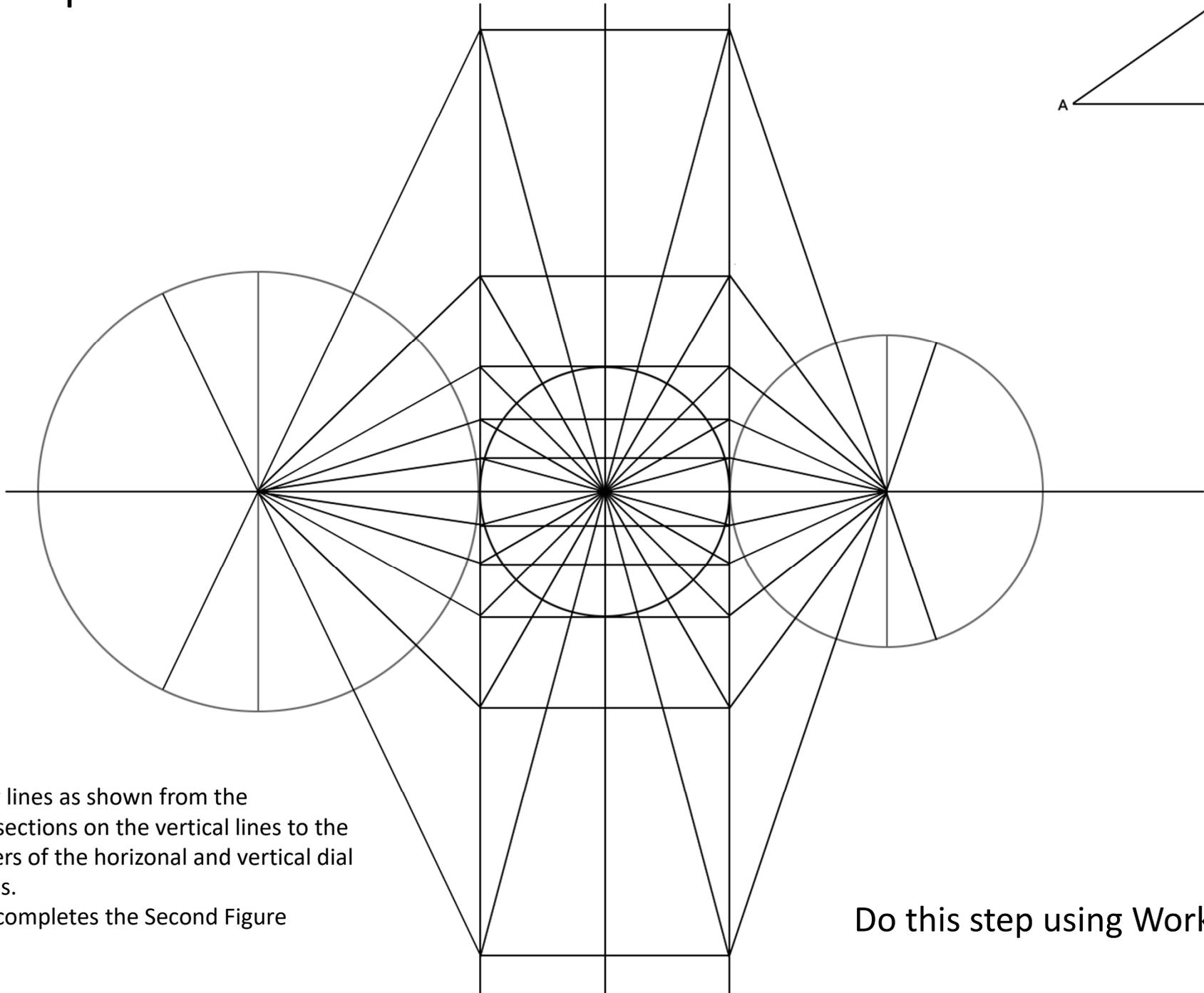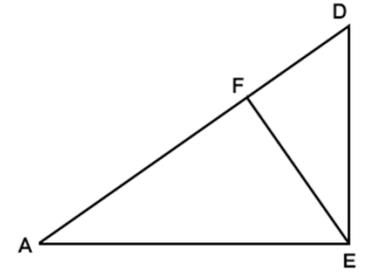
Do this step using Worksheet 5

Step 6

1. Construct the horizonal and vertical dial circles using AE and DE respectively from the First Figure, making them tangent to the vertical lines and the equatorial circle.
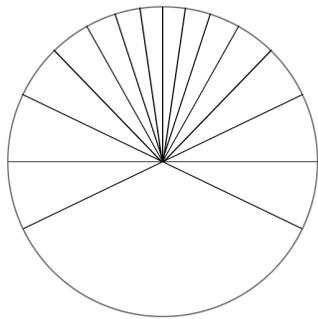2. Raise perpendicular lines from the center of the horizonal and vertical dial circles
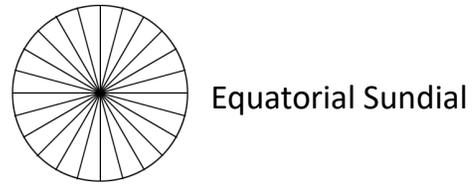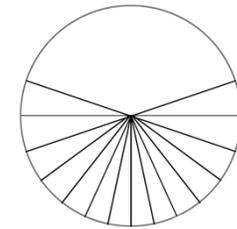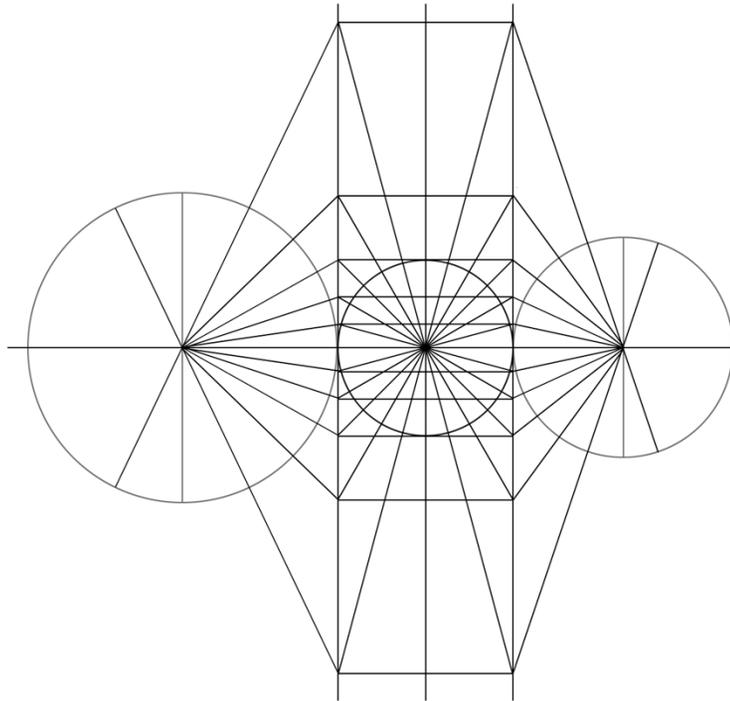
Do this step using Worksheet 5

Step 7

1. Draw lines as shown from the intersections on the vertical lines to the centers of the horizonal and vertical dial circles.
2. This completes the Second Figure

Do this step using Worksheet 6
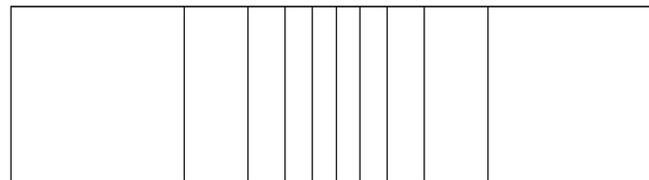
Breaking out the Dials

Equatorial Sundial

Horizonal Sundial

Vertical Sundial

Note: the height of the blade gnomon for the polar sundial is equal to the radius of the equatorial dial (EF in the First Figure.

Polar Sundial

References

Hartmann, Georg. *Hartmann's Practika*. Translated by John Lamprey. John Lamprey, 2002.

Finé, Oronce. *Oronce Finé's First Book of Solar Horology (1560)*. Translated by Peter Drinkwater. P. Drinkwater, 1990.

Finé, Oronce. *Oronce Finé's Second Book of Solar Horology (1560)*. Translated by Peter Drinkwater. P. Drinkwater, 1993.

Finé, Oronce. *Oronce Finé's Third and Fourth Books of Solar Horology (1560)*. Translated by Peter Drinkwater. P. Drinkwater, 1993.

Drinkwater, Peter. *The Art of Sundial Construction*. P. Drinkwater, 1987.

Resources for Geometric Construction:

Websites:

https://www.euclidea.xyz/

https://www.khanacademy.org/math/geometry-home/geometric-constructions

https://www.cuemath.com/geometry/geometric-construction/

Electronic tablet apps:

Euclidea

Euclidea: Sketches