

SPHERE

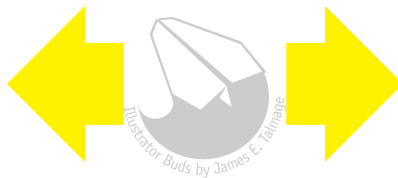
Constructing a Latitude / Longitude grid

1.

To get started, we need some numbers.

Text Tool: Somewhere out of the way on your page, create a text object and type the text shown.

Tilt Angle:
Tilt Sine:
Tilt Cosine:



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2.

Decide upon an angle (in degrees) at which you want the axis of your globe to be tilted.

Looking edge-on at the equator would be zero degrees; looking straight down at the north pole would be 90 degrees.

In this example, I'm using 30 degrees.

Enter the angle in your text field.

Launch Windows Calculator.

From the View menu, select Scientific.

Select the Decimal radio button.

Select the Degrees radio button.

Enter your degree angle then click the Sin button. Copy the resulting value.

Switch back to Illustrator and paste the value into your text object.

Tilt Angle: 30°

Tilt Sine: 0.5

Tilt Cosine:



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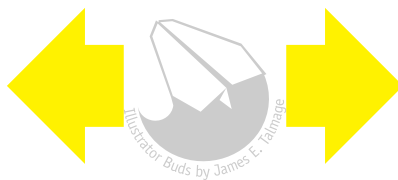
Constructing a Latitude / Longitude grid

3.

Switch back to Calculator. Clear the entry. Similarly obtain the Cosine of your tilt angle. (Three decimal places is a gracious plenty.) Copy it and paste it into your text object.

You may goof up a few times during this construction. The text object is just to serve as a reference if you need to recall the values.

Tilt Angle: 30°
Tilt Sine: 0.5
Tilt Cosine: .866



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Constructing a Latitude / Longitude grid

4.

Okay. We've got the values we need to get started.

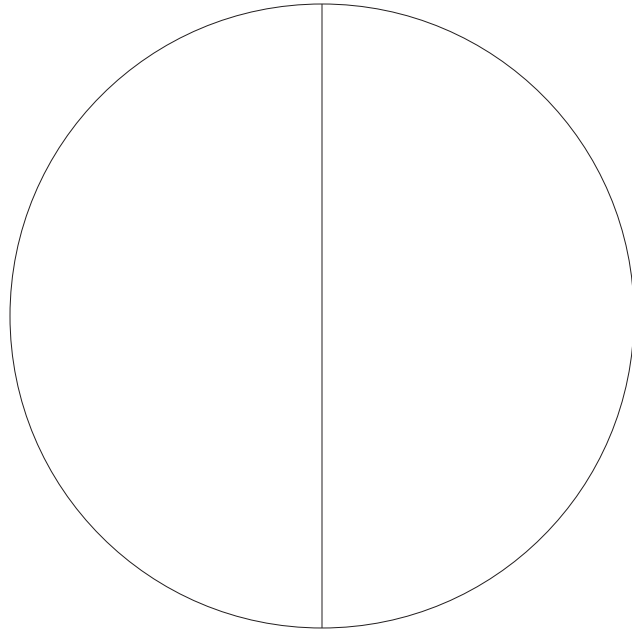
Turn SmartGuides on.

Ellipse Tool:

ClickShiftDrag to create a circle. This is the horizon of our globe.

Line Tool:

Mouseover the top point of the circle. When SmartGuides indicates you are over the anchor point, clickDrag downward to the anchor point at the bottom of the circle. This is the axis of our globe. Leave it selected.



Tilt Angle: 30°

Tilt Sine: 0.5

Tilt Cosine: .866



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Constructing a Latitude / Longitude grid

5.

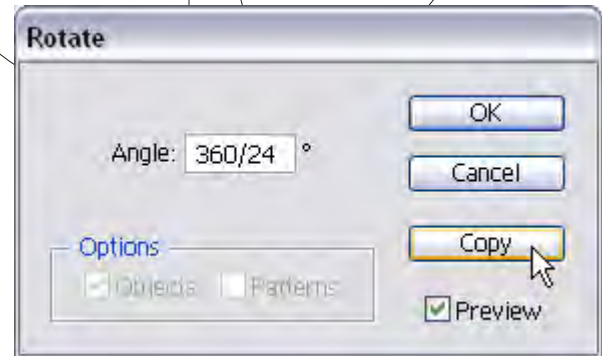
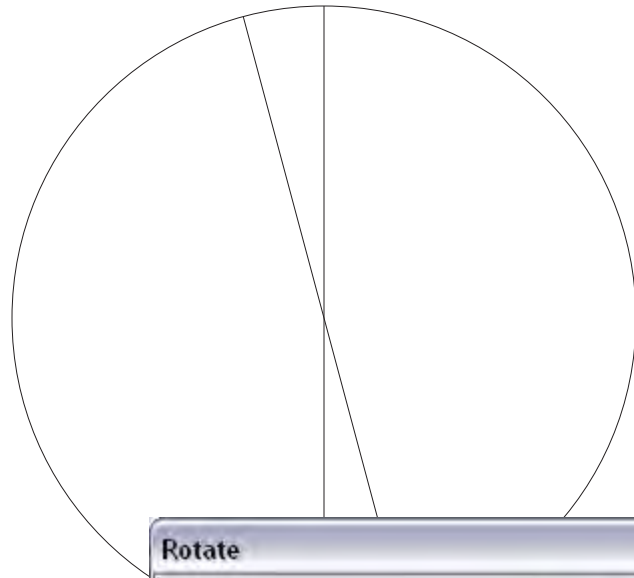
DoubleClick the Rotate Tool.

Decide how many longitude lines you want in terms of their radial increment.

I've chosen to have longitude lines at 15° increments.

Note that you can enter values as a simple math expression if you want to. Just enter 360 divided by the number of lines desired.

Click Copy.



Tilt Angle: 30°
Tilt Sine: 0.5
Tilt Cosine: .866



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Constructing a Latitude / Longitude grid

6.

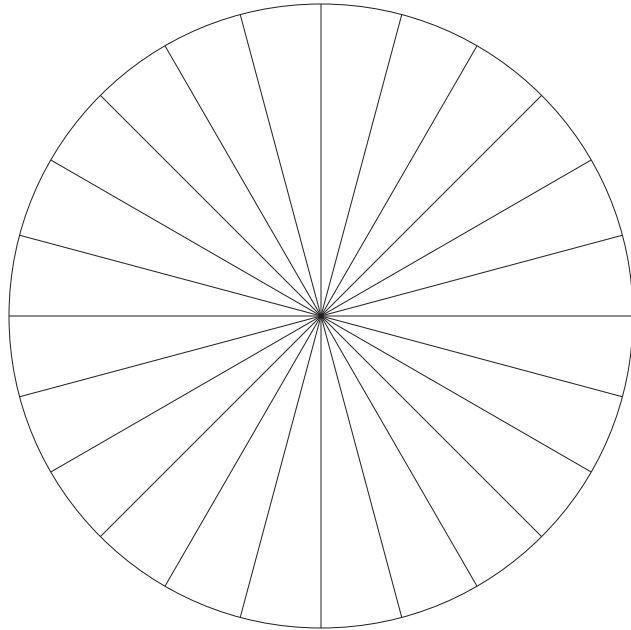
Tap Ctrl-D (Transform Again) until the copies sweep 180°.

Select the circle and copy it to the clipboard. We will need to paste additional circles in place soon.

Now...

Start thinking of this figure as a "side view" of your globe. The vertical line is the axis. The other lines are angular locators for each line of longitude. The horizontal line is the equator.

Select everything and Object>Lock.



Tilt Angle: 30°
Tilt Sine: 0.5
Tilt Cosine: .866



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Constructing a Latitude / Longitude grid

7.

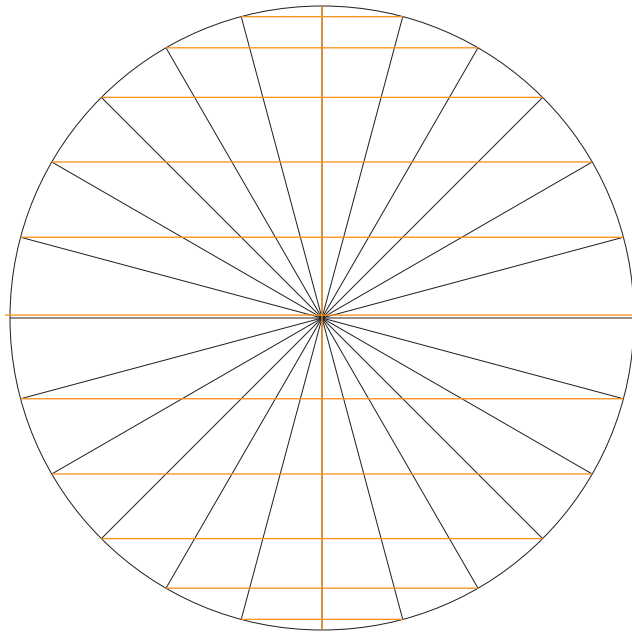
Change the current stroke color to orange.

Line Tool:

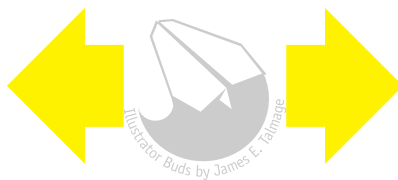
Letting SmartGuides indicate when you are at the end points of the diagonal lines, draw a horizontal line across the "side view" of the globe at each latitude.

These are the "side views" of each latitude circle.

Draw a vertical line along the axis.



Tilt Angle: 30°
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Tilt Cosine: .866



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Constructing a Latitude / Longitude grid

8.

Selection Tool (black pointer):

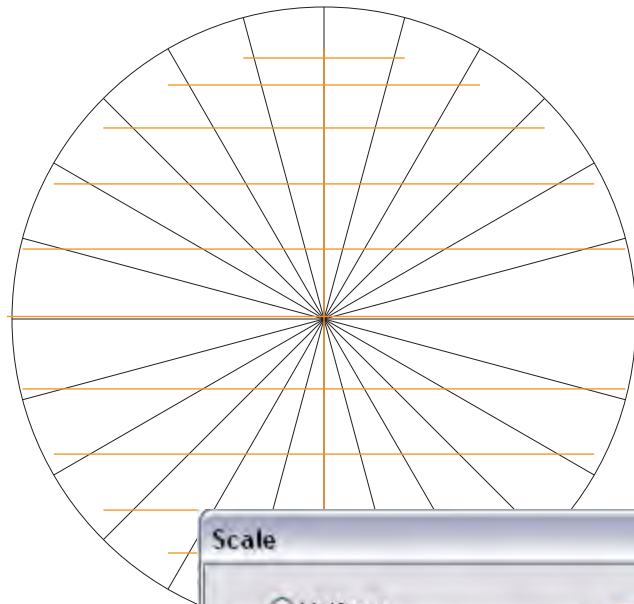
Drag a selection marquee around all the orange stuff.

Now imagine what would happen in this side view if the axis tilted directly toward you, rotating about its center.

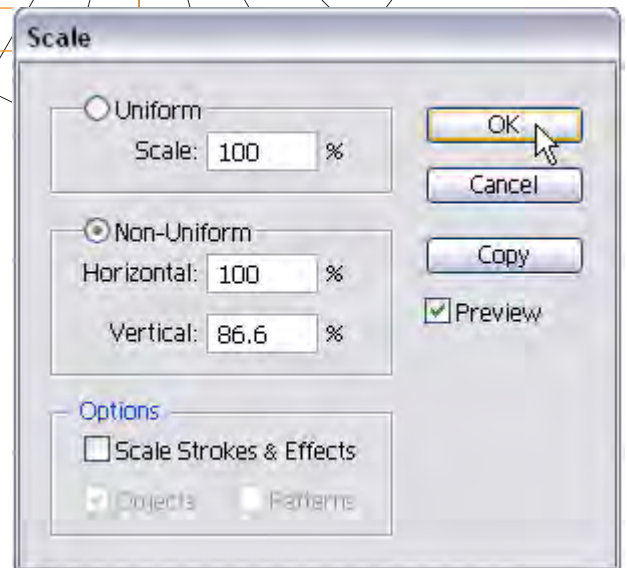
The axis would become foreshortened in height. How much? It would shorten by a factor equal to the cosine of the amount it tilted.

DoubleClick the Scale Tool. Key in 100% for horizontal scale; and the cosine of your angle expressed as a percentage for the vertical scale.

Click OK.



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Tilt Cosine: .866



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Constructing a Latitude / Longitude grid

9.

This is still a "side view" of our globe under construction. But the globe has rolled toward us 30 degrees. This makes the axis appear foreshortened.

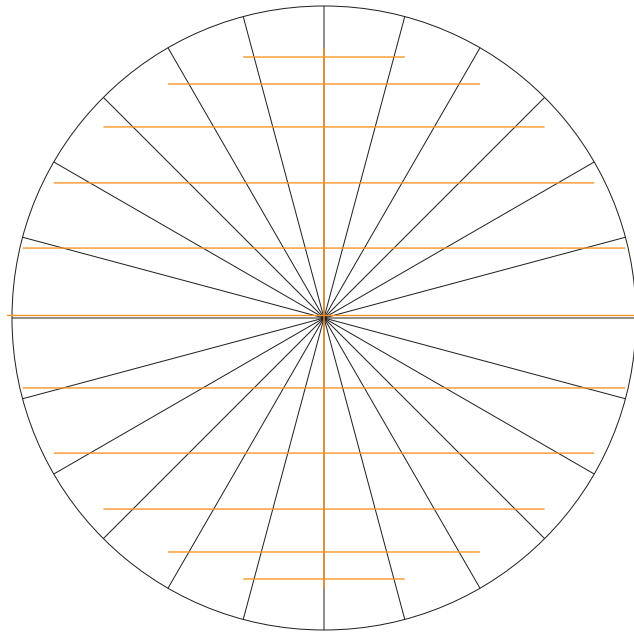
Of course, measures along the axis have also been foreshortened. That's why we included the latitude lines in the scaling.

But of course, if those orange latitude lines were the "side view" of circles, they should now look like ellipses. So "shift mental gears" again and think of those orange horizontal lines not as the longitude circles themselves, but as diameters of the longitude circles.

Note that their widths did not change in the scaling we performed; only their spacing did. This is because they represent the diameters which are perpendicular to our line of sight. In other words, they are the diameter about which each (presently invisible) latitude circle has rotated.

What we have here in the horizontal orange lines is the proper altitude along the foreshortened axis for each longitude. And because the orange lines are unforeshortened diameters of the longitude lines, they also indicate the major diameters of each longitude ellipse.

But what about the height of the ellipses?



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Constructing a Latitude / Longitude grid

10.

Well, the height of the equator ellipse is very easy: It is the sine of our tilt angle.

Deselect.

Paste In Front.

The circle we copied in step 6 pastes in place. (I've colored it orange.)

DoubleClick the Scale Tool.

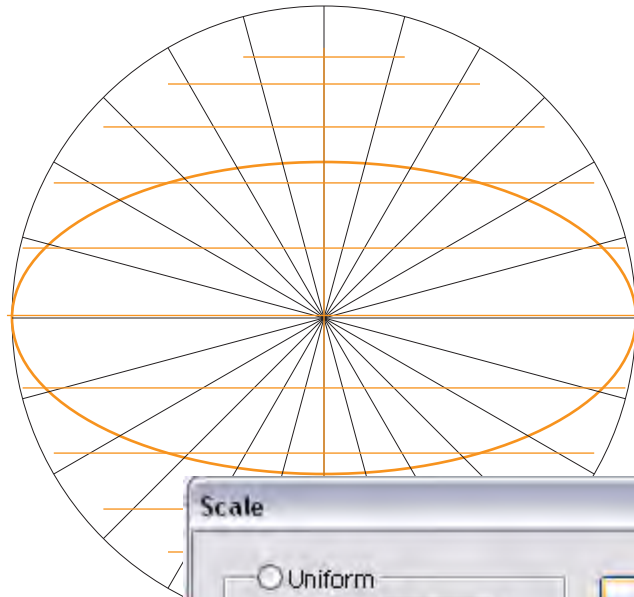
Horizontal is still set to 100%

Set vertical to the sine of our tilt angle.

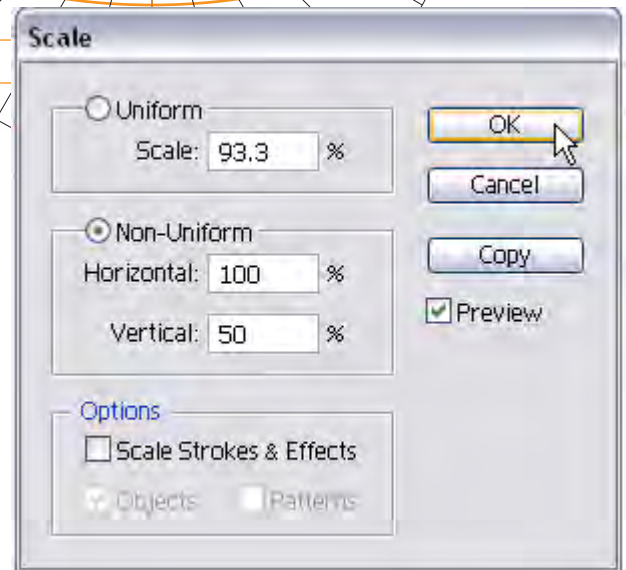
Click OK.

This is what the equator circle looks like when it is rolled toward us 30° .

Of course, all the other latitude lines will be proportioned just like this, because they are tilted toward us at the same angle. So...



Tilt Angle: 30°
Tilt Sine: 0.5
Tilt Cosine: .866



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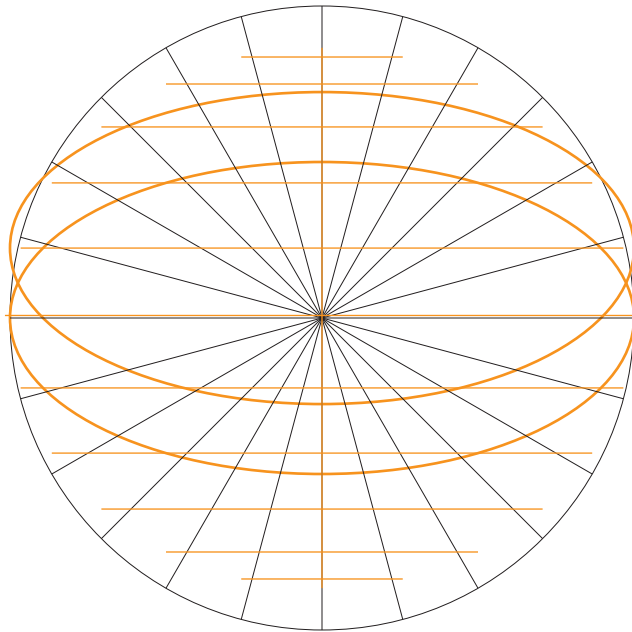
Constructing a Latitude / Longitude grid

11.

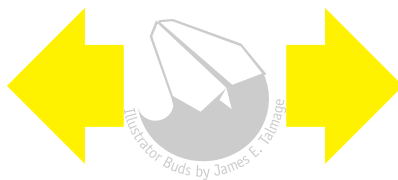
Selection Tool:

Mouseover the centerpoint of the ellipse. SmartGuides will indicate "Center" when you find it. (If the center dot isn't showing, click the Show Center icon in the Attributes Palette.)

Mousedown on the centerpoint and AltShiftDrag a copy straight upward, stopping when Smart Guides indicates you have intersected the first latitude radius north of the equator.



Tilt Angle: 30°
Tilt Sine: 0.5
Tilt Cosine: .866



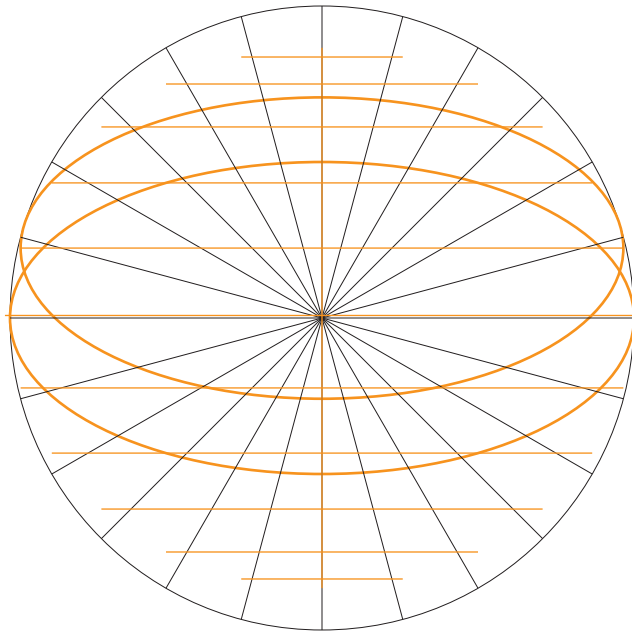
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12.

Selection Tool:

Mouseover the right side bounding box handle. Mousedown, press Alt and Shift, and drag slowly toward the left. The ellipse scales about its center, and proportionally. Stop dragging when SmartGuides indicates you have reached the endpoint of the orange diameter line.



Tilt Angle: 30°
Tilt Sine: 0.5
Tilt Cosine: .866



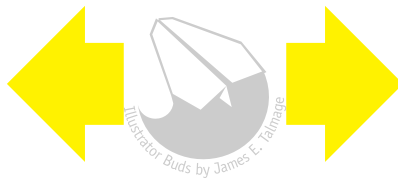
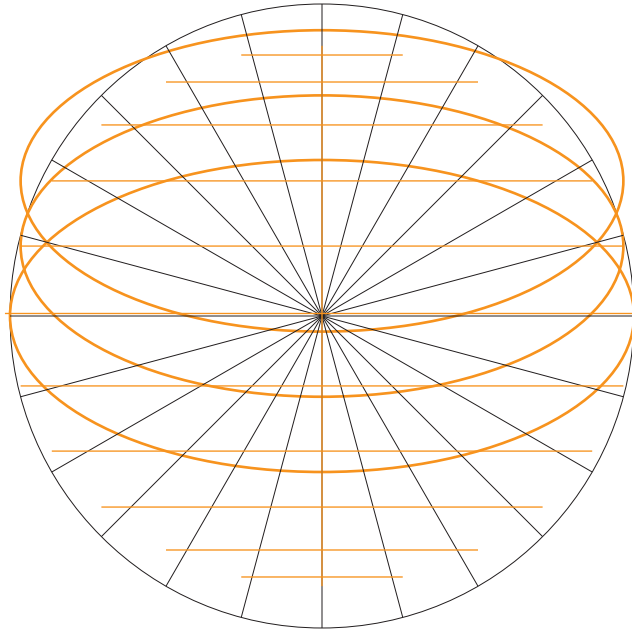
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13.

Selection Tool:

Mouseover the center of this ellipse. Mousedown and AltShiftDrag another copy to the next northward latitude diameter.



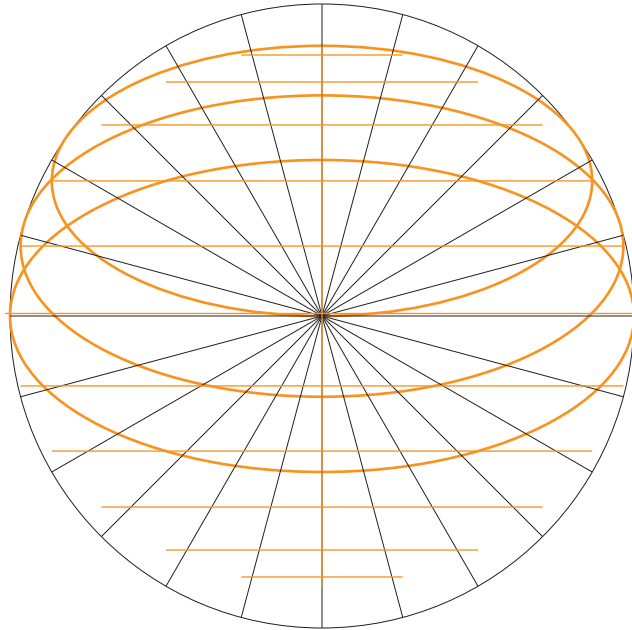
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Constructing a Latitude / Longitude grid

14.

Selection Tool:

Mouseover its right side bounding box handle.
AltShiftDrag to scale it proportionally until it is the width of the latitude diameter line.



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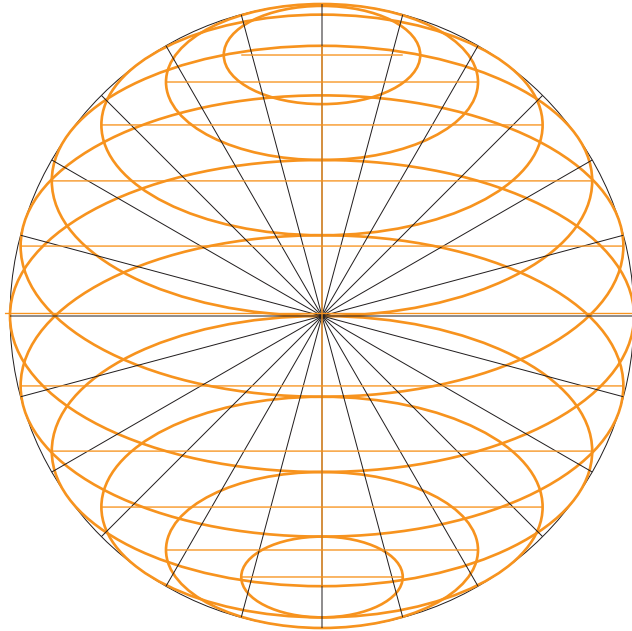
15.

And so on for the rest of the northern latitudes

Go back to the equator and do the same thing for the southern hemisphere.

Our set of latitude lines is complete.

Now for the longitudes.



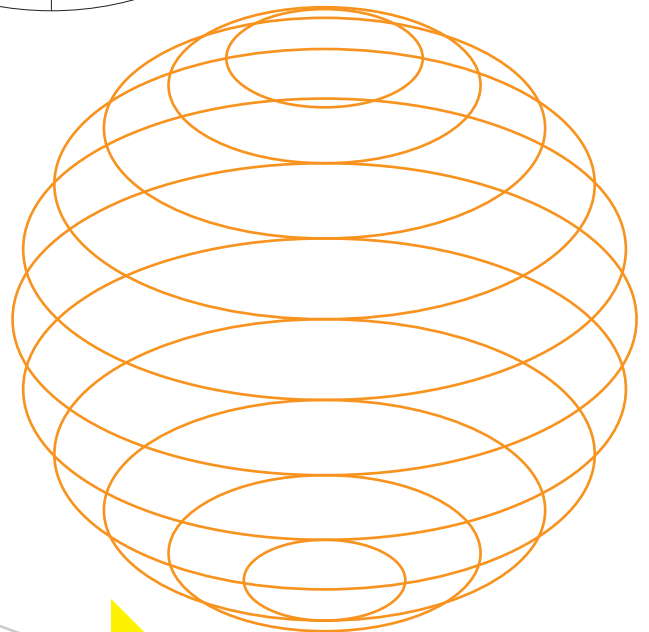
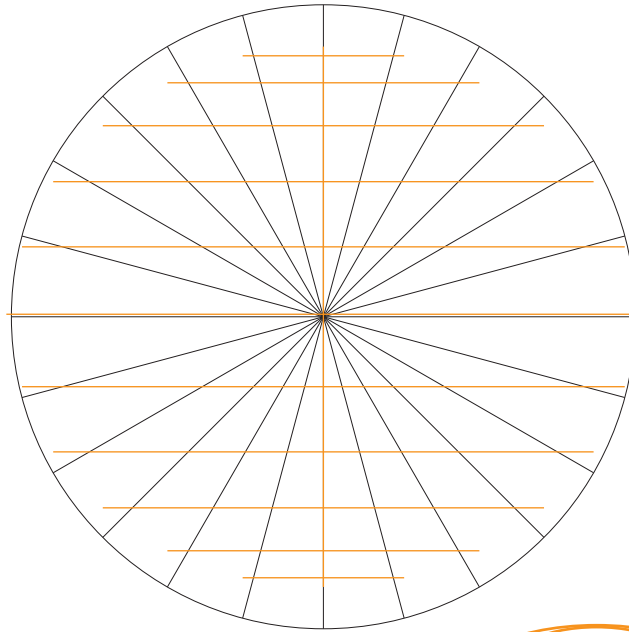
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Constructing a Latitude / Longitude grid

16.

Select all the latitudes, group them, and drag the Group off to the side so our view will be less cluttered as we work on the longitude lines.

But leave the latitude diameter lines where they are.



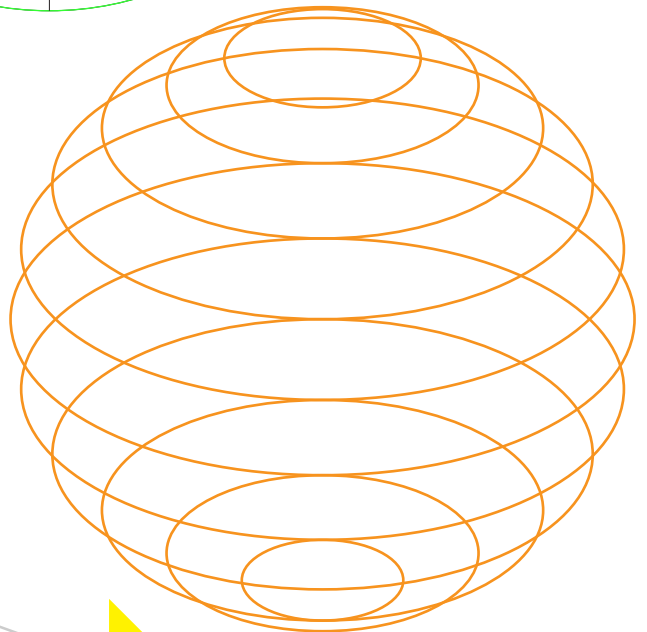
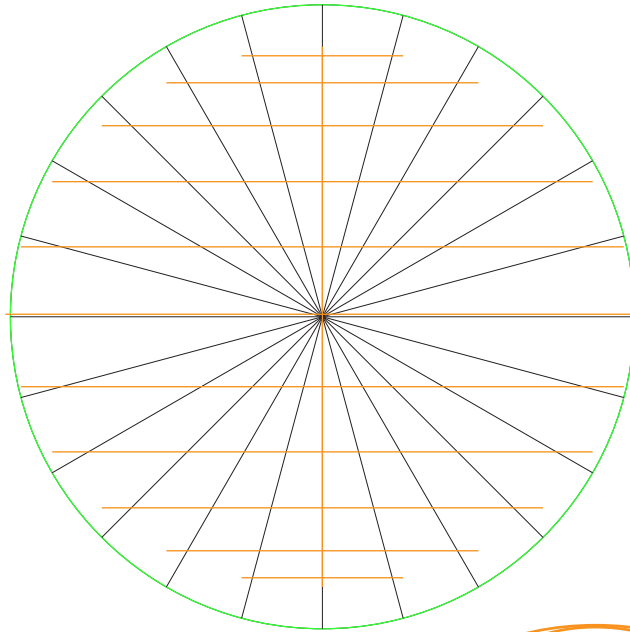
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Constructing a Latitude / Longitude grid

17.

Paste In Front.

Another circle appears. Stroke
this one with green.



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18.

Paste In Front.

Another circle appears. Stroke this one with green.

Selection Tool:

AltDrag the top center bounding box handle straight downward until SmartGuides indicates you have reached the north pole.

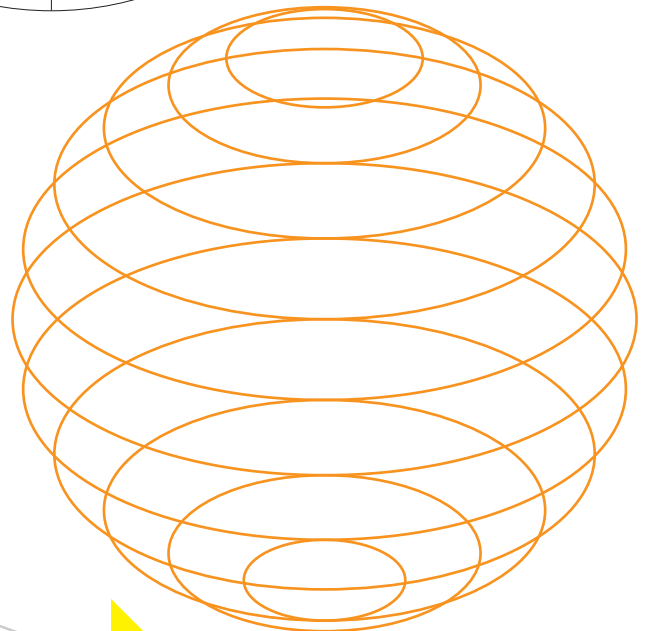
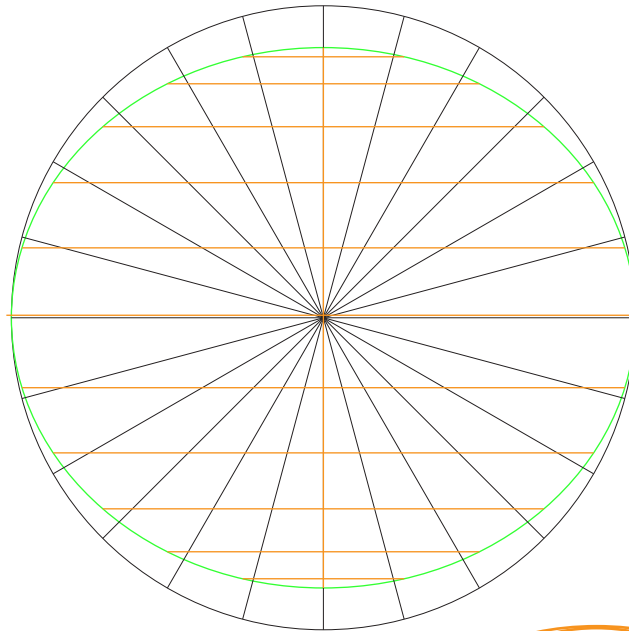
Now look at the drawing and consider what this ellipse represents.

It started as a circle identical to our horizon circle. It was the "great circle" of the sphere as viewed from our vantage point.

It was the only completely unforeshortened circumference of the globe, because it was the circumference perpendicular to our line of sight.

By scaling it vertically, we "tilted" it toward us 30°.

It is a longitude line, so of course it crosses both the tips of the north and south poles. Note how neatly it now also "happens" to describe the latitude diameters we have been working with.



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Constructing a Latitude / Longitude grid

19.

Copy.

Paste In Front.

AltDrag the top middle handle of the copy's bounding box down to where the first horizontal orange line intersects the vertical axis.

Now here we have the next longitude ellipse. It's foreshortened more than the first one as it should be. But this one needs to be different, because it has to be rotated in two planes, not just one. That is, before it was "rolled toward us", it would have been "rotated" relative to our line of sight, because longitude circles are not parallel.

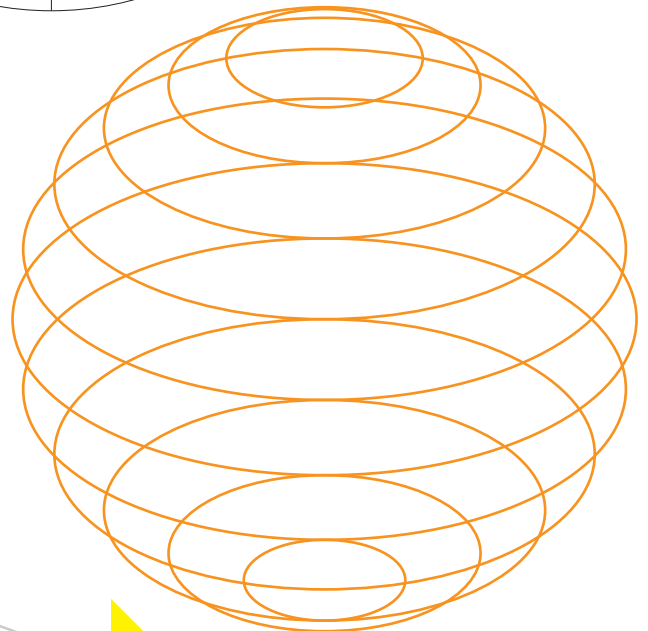
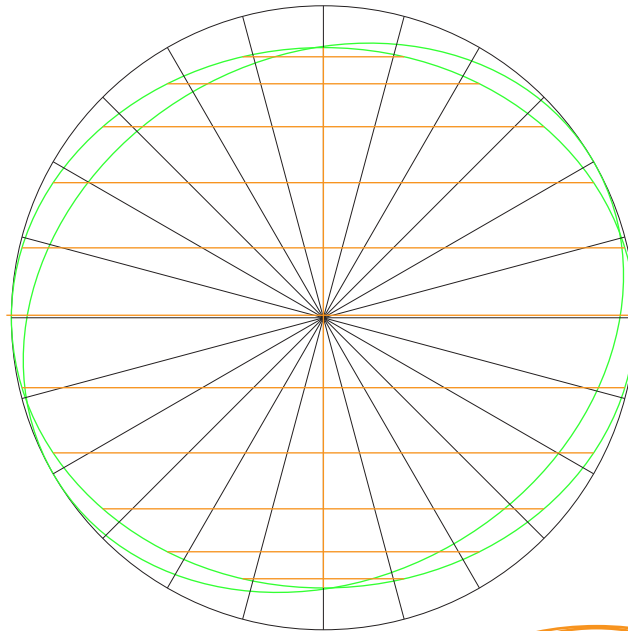
So what do we do?

Thankfully, we have a handy mechanism to make things right staring us right in the face: the north pole.

All longitude circles cross at the poles. Therefore...

DoubleClick the Rotate tool.
Enter 1° for the rotate angle.
Click OK.

Press Ctrl and tap D repeatedly while watching the edge of the ellipse. Stop when the edge neatly crosses the endpoint of the north pole.



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Constructing a Latitude / Longitude grid

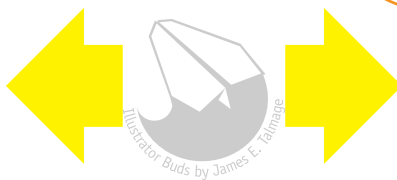
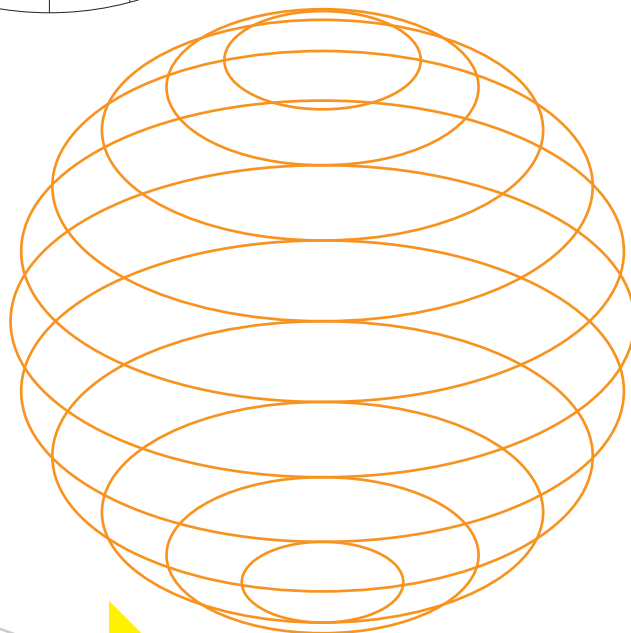
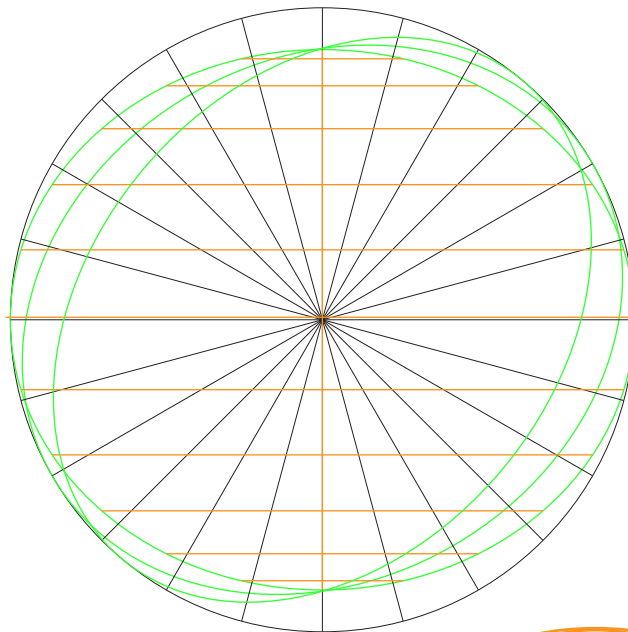
20.

Paste In Front.

As before, AltDrag the top middle handle of the copy's bounding box down to where the second horizontal orange line intersects the vertical axis.

DoubleClick the Rotate tool. 1° is still entered, so just click OK.

Press Ctrl and tap D repeatedly while watching the edge of the ellipse. Stop when the edge neatly crosses the endpoint of the north pole.

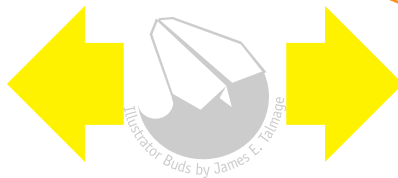
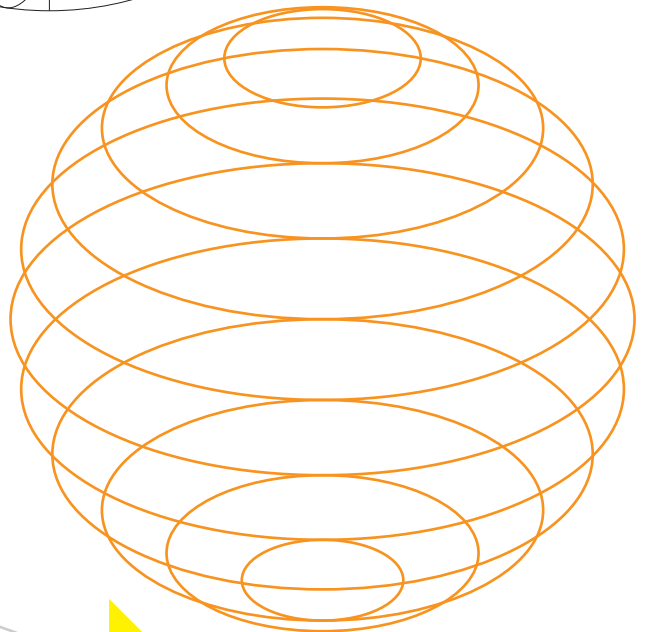
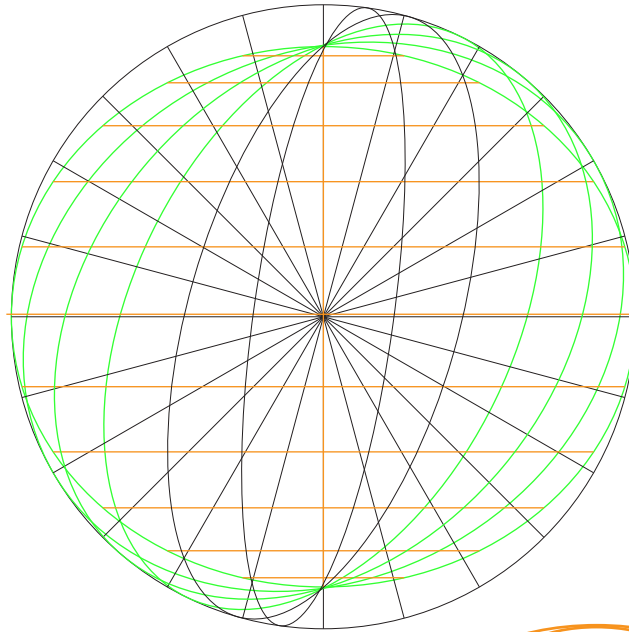


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21.

And so on until you have done a longitude ellipse for one half of the sphere.



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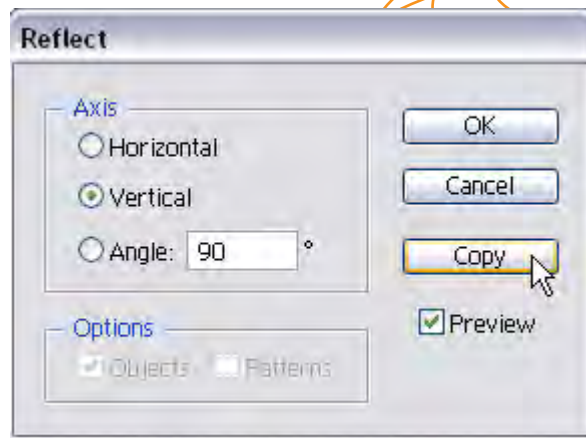
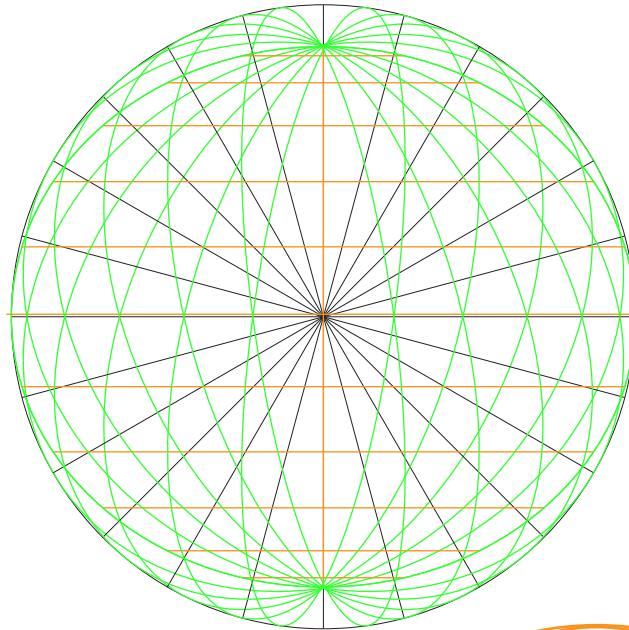
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22.

Select the green longitude lines.

DoubleClick the Reflect tool.
Select the Vertical radio button
and click Copy.

You now have all the longitude lines except for the center one,
which we are viewing :“edge
on.”



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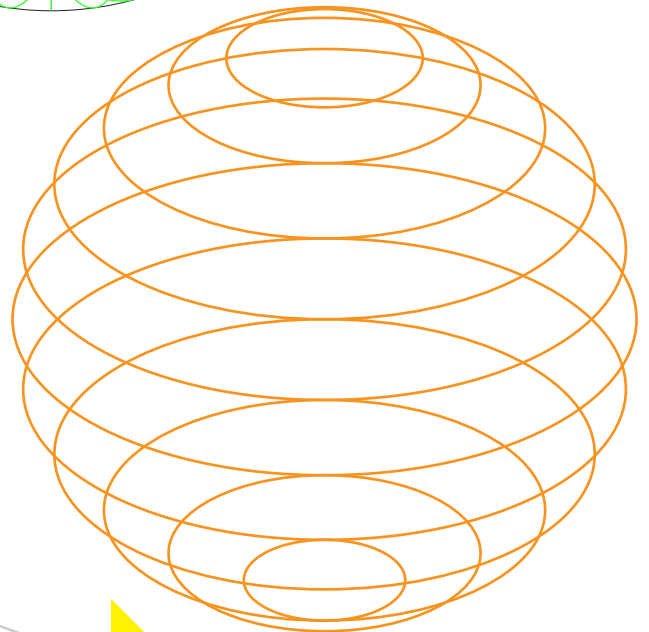
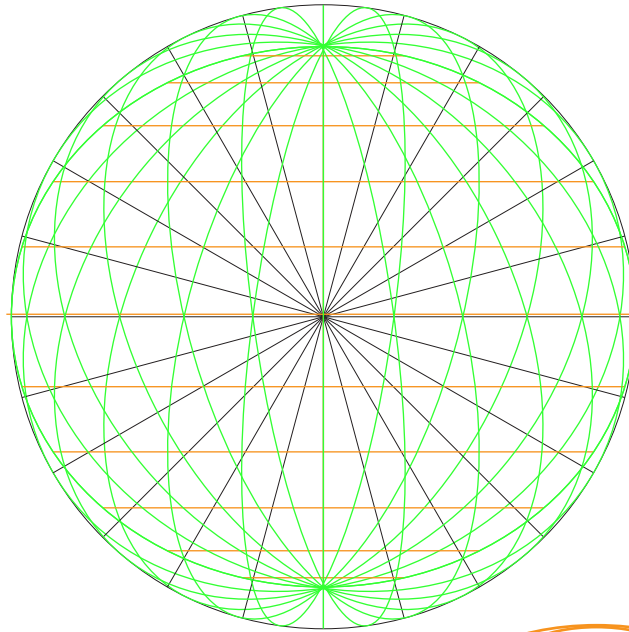
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23.

Line Tool:

Draw a vertical line all the way across the great circle of the globe.

Now we have the full set of longitude lines.



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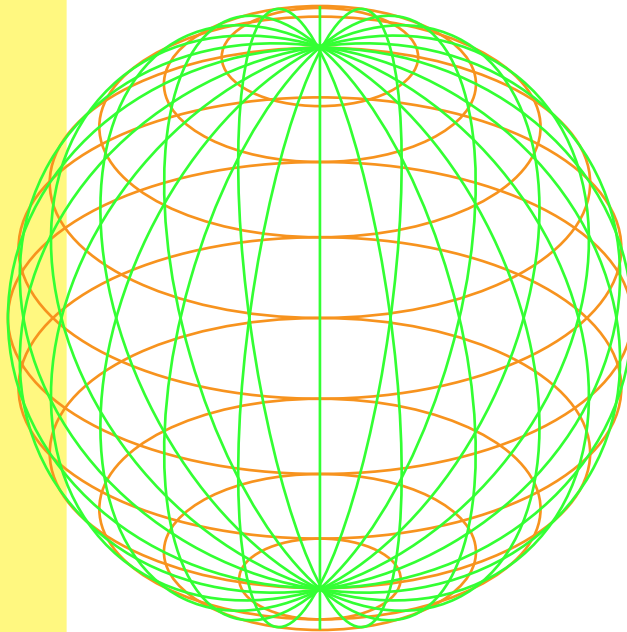
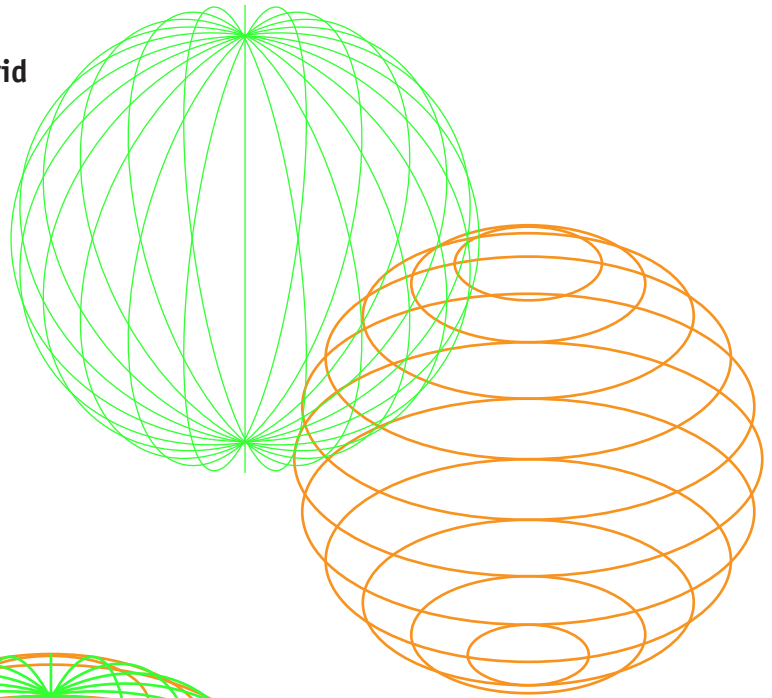
24.

Select all the longitude lines.
(If you've been using a unique color for these, you can use Select>Same>Stroke Color.)

Group.

Shift select the latitude Group to add it to the selection.

Align the two Groups horizontally and vertically.



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Constructing a Latitude / Longitude grid

25.

Rotate the whole thing and Stylize as desired, then correct stacking order as needed.

Depending upon how you stylize the thing, you may want to split the ellipses to send half of them to the rear, or to delete the “back” halves.

Longitude lines always touch the horizon circle at their major diameters, so their “back sides” can be removed by simply selecting and deleting one point.

Latitude lines will have to be cut where they contact the horizon circle.

