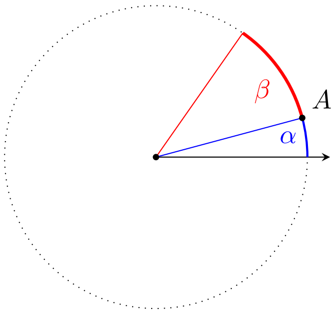
ARCS IN TIKZ

8DCC

When I started reading about arcs in Ti*k*Z, the LaTeX graphics library, I had some trouble understanding how they worked. This short explanation (made with Ti*k*Z itself) might help someone who is looking for more information.

1. Syntax

A Ti*k*Z arc is just a portion of a circumference that starts at an angle α and ends at an angle β.



Where the red arc, representing the angle β, is what we are trying to draw. The arc starts at point A, which itself is at an angle α relative to the positive horizontal.

These are the two main ways of declaring an arc in Ti*k*Z, both are equivalent:

```
\draw (X,Y) arc (START:END:RADIUS);
\draw (X,Y) arc [start angle=START, end angle=END, radius=RADIUS];
```

The (X, Y) point does not represent the center of the circumference, but the point where the arc itself starts, which was named A in the previous example.

You also need to provide the *start* angle of the arc. This angle, in degrees, is relative to the positive horizontal axis. In the previous example, it was the blue angle, named α. The *end* angle indicates where the arc will end on the circumference, and is **not** relative to the start angle α, but relative to the positive horizontal axis. In other words, it expects an angle relative to the horizontal, instead of the angle of the arc we are trying to draw.

Finally, it expects the *radius* of the circumference. That is, the distance between the *start point* and the center of the "hypothetical" circumference where the arc is. If you are, for example, drawing an arc to represent the angle between two lines, the radius will probably be the distance between the start of your arc and the vertex where the lines join, which would be the center of this "circumference".

Note how we didn't specify the center of the circumference ourselves, but the arc function will calculate it with the *start point*, *start angle* and *radius* values. Specifically, it calculates the center of the circumference with the following formula:

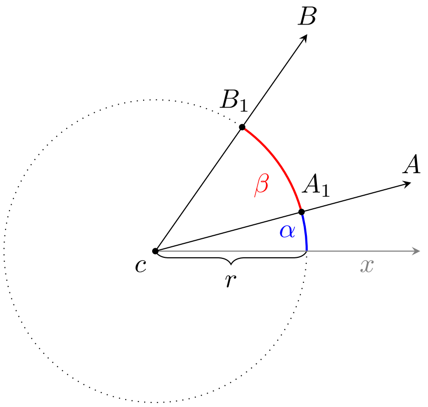
$$C_x = A_x - r\cos\alpha$$
$$C_y = A_y - r\sin\alpha$$

Therefore, we can also calculate the A (and optionally B) positions if we already know the *center*, *radius* and *start angle* with the following formula:

$$A_x = C_x + r\cos\alpha$$
$$A_y = C_y + r\sin\alpha$$

2. Example

Let's look at a more specific example of how an arc would be drawn. Imagine we wanted to draw the arc representing the β angle formed by the A and B lines.



Note that the arc will be drawn from A_1 to B_1, not the other way around.

We should know, at least, the distance from the center c where the arc will be drawn inside the line A. This is the radius r of the circumference. Perhaps we don't know specifically where the A_1 point will be, but we can calculate it with some simple trigonometry:

```
% Radius of the circumference.
\pgfmathsetmacro{\Radius}{2}

% Center of the circumference, vertex where A and B join.
\pgfmathsetmacro{\OriginX}{0}
\pgfmathsetmacro{\OriginY}{0}

% Angle in degrees where the arc Alpha ends.
\pgfmathsetmacro{\ArcAngleAlpha}{15}

% Calculate A1 point, from the Center, Radius and Angle.
\pgfmathsetmacro{\AlphaX}{\OriginX+\Radius*cos(\ArcAngleAlpha)}
\pgfmathsetmacro{\AlphaY}{\OriginY+\Radius*sin(\ArcAngleAlpha)}

% Define the coordinate for the A1 point, for convenience.
\coordinate (a1) at (\AlphaX, \AlphaY);
```

With that, we can draw our arc using the vertex as the center of the "circumference":

```
% Angle in degrees where the arc Beta ends. Relative to ‘x’.
\pgfmathsetmacro{\ArcAngleBeta}{40}

% Draw the arc itself.
\draw[thick, red] (a1)
    arc[start angle=\ArcAngleAlpha,
        end angle=\ArcAngleAlpha + \ArcAngleBeta,
        radius=\Radius];
```

We are drawing a thick red arc, starting at point A_1, which is at 15 degrees in a hypotetical circumference of radius 2. The arc ends at 40 degrees relative to x.

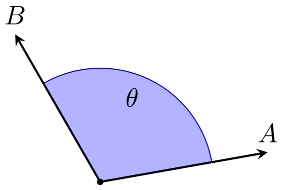
3. Filling the arc

If we wanted to fill the arc, we would need to use `\filldraw` instead of `\draw`, and we would have to manually specify the origin of our "circumference". We would also need to add `cycle` at the end:

```
% Without filling
\draw[blue] (a1) arc (15:55:2);

% With filling
\filldraw[blue, fill opacity=0.3] (o) -- (a1) arc (15:55:2) -- cycle;
```

This is the result:



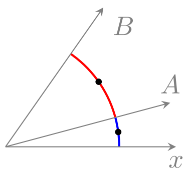
4. Getting the position for the labels

To get the positions where the α, β and θ labels will go, you just need to calculate the point in the middle of the arc. Just divide the angle of the arc by two, and calculate the point like we did before. This is the code used for getting the labels of section 2:

```
\pgfmathsetmacro{\AlphaLabelX}{\OriginX+\Radius*cos(\ArcAngleAlpha/2)}
\pgfmathsetmacro{\AlphaLabelY}{\OriginY+\Radius*sin(\ArcAngleAlpha/2)}

\pgfmathsetmacro{\BetaLabelX}{\OriginX+\Radius*cos(\ArcAngleAlpha+(\ArcAngleBeta/2))}
\pgfmathsetmacro{\BetaLabelY}{\OriginY+\Radius*sin(\ArcAngleAlpha+(\ArcAngleBeta/2))}
```

In the following image, the dots in black represent the points for the labels. The actual label text would be calculated relative to that.



References

[1] TikZ and PGF Manual for version 1.18, 2007. Section 11.8, The Arc Operation. `https://www.bu.edu/math/files/2013/08/tikzpgfmanual.pdf`

[2] `https://tikz.dev/tutorial`

[3] `https://tex.stackexchange.com/q/175016/292826`

[4] `https://tex.stackexchange.com/q/54142/292826`

[5] `https://tex.stackexchange.com/q/62128/292826`