

# Miniproject 4 – Paul Klee museum



## Topics

1. Mastering tree data structure
2. Create and handle complex curve geometries

## List of relevant components used

- Point Decompose
- Evaluate Curve
- Offset
- Cosine
- Range
- Graph Mapper

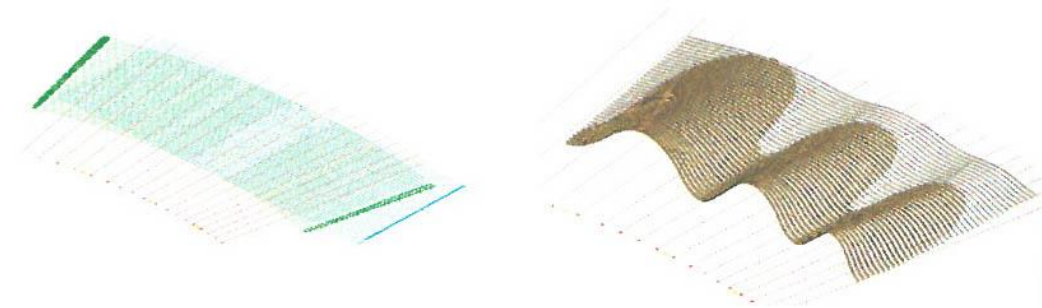
## Introduction

A series of diminishing “Waves” on a concentric grid forms the roof structure of the “Zentrum Paul Klee ” in Berne/Switzerland, designed by Renzo Piano (2004). Because of their changing curvature and size, the final geometry is the result of quite complex interdependencies.

To accompany and support the design process, a parametric model was developed. It enabled the architects to test countless alternative solutions until the final design was determined. And in a final step, it was used to generate the construction documents for the steel contactors.

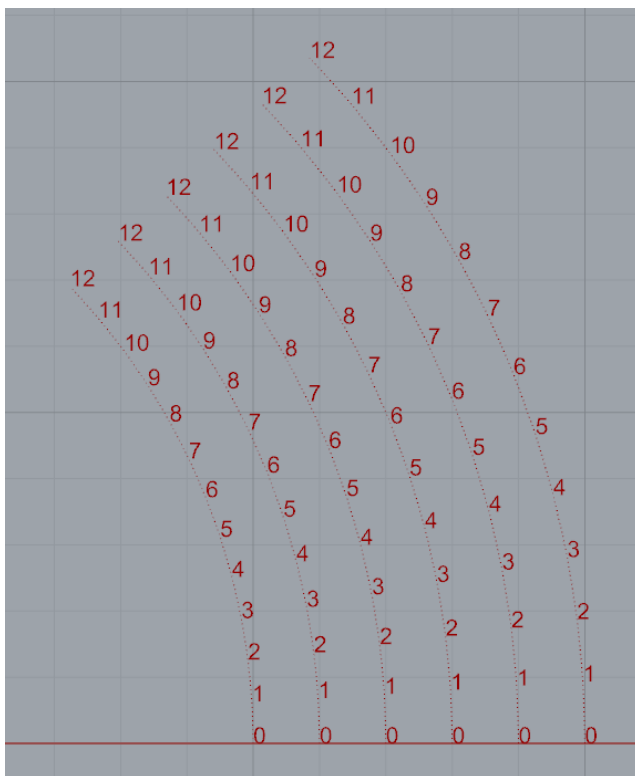
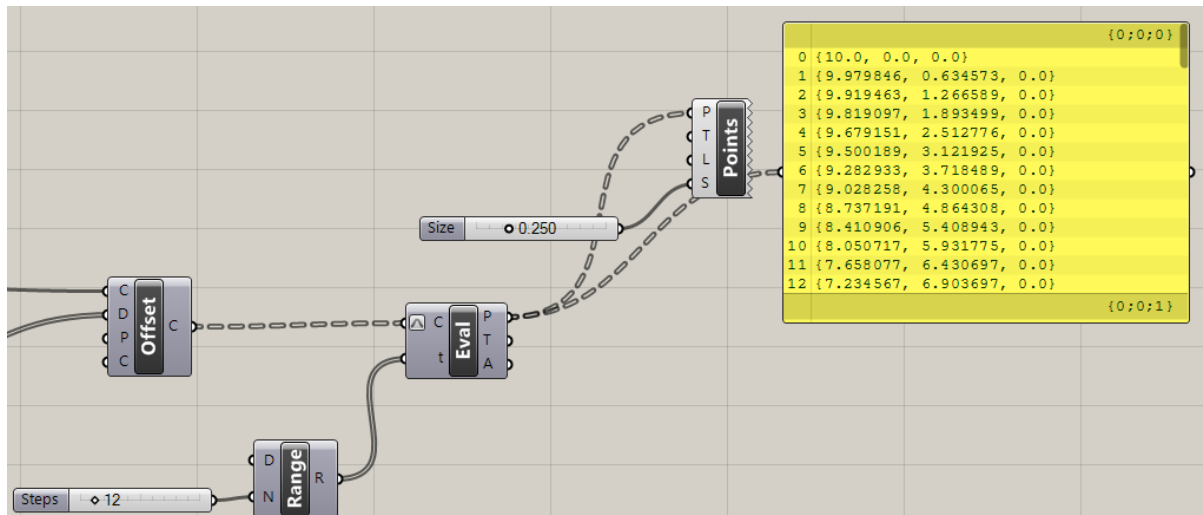
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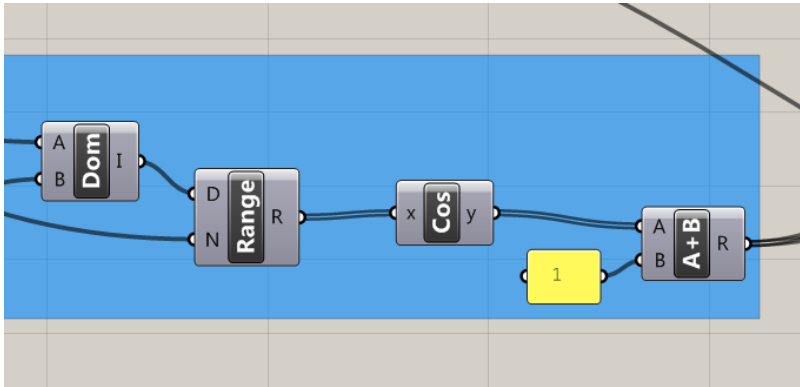


## Procedure

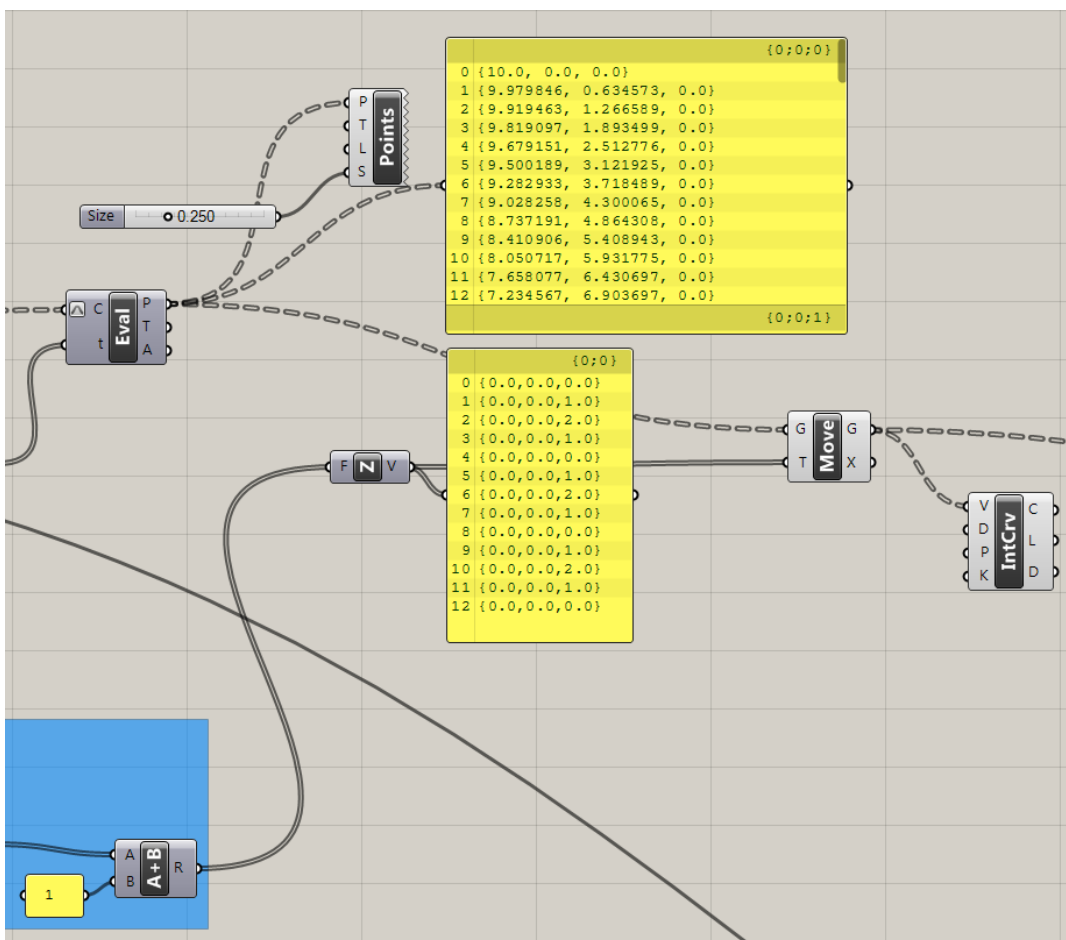
- 1- The points on the 2d grid are organized along a series of concentric arcs. The number of points on the arcs and the number of arcs should be defined parametrically.
- 2- Define an arc with Arc component (Curve>Primitive) and appropriate slider inputs
- 3- To create concentric arcs, offset the initial arc with Offset component (Curve>util). To create more than one concentric arc, input in “D” input more than one offset distance (it is recommended to use a Range component for this purpose with appropriate inputs)
- 4- Create points on the arches with Eval component. It is recommended to create at least 13 points on each arc. Reparametrize Eval “C” input (right click>reparametrize) in order to set each arc evaluation domain from 0 to 1. A series of number comprised from 0 to 1 should be used as evaluation parameters values (it is recommended to use a Range component for this purpose with appropriate inputs).

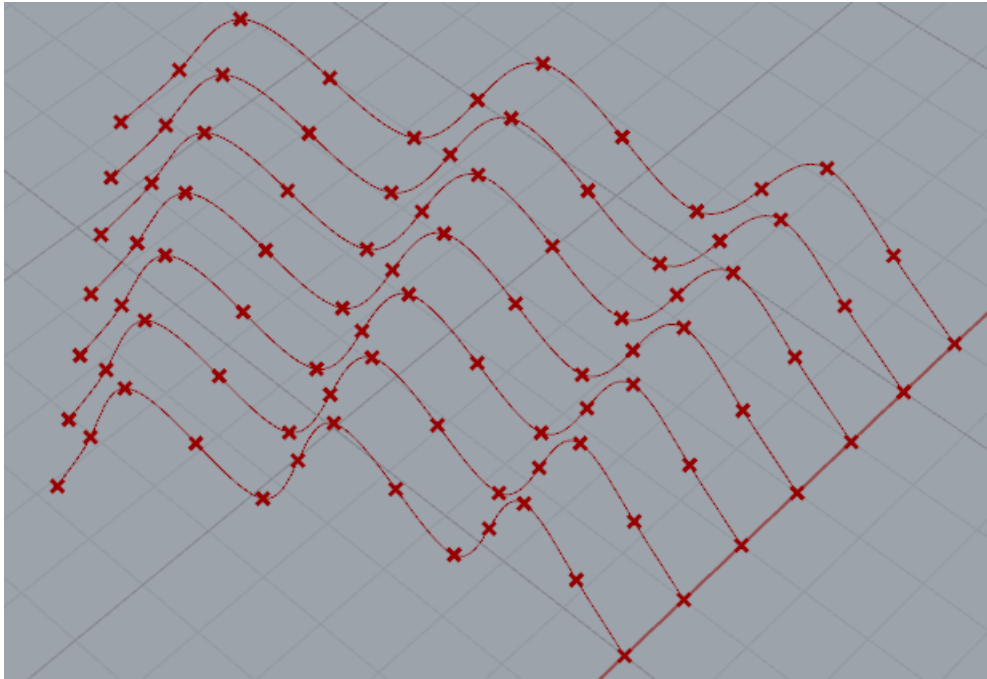


- 5- In order to create cosine wave geometry **move** the points vertically (in the z direction if the grid is drawn in the xy plane) using a move component and appropriate “T” translation vectors input. Translation vectors input can be set by using a **unit z** component as a unit direction vector, then a series of factors computed from a **cosine** function (math>trig) to create a list of vectors with z direction and variable length.
- Use a **Range** component to set the cosine input numbers, and a **Domain** (math>domain >construct domain) to set the appropriate cosine function range in order to get the three characteristic museum waves. Because cosine output can range from -1 to 1, in order to have always positive values one should add 1 to the function output.

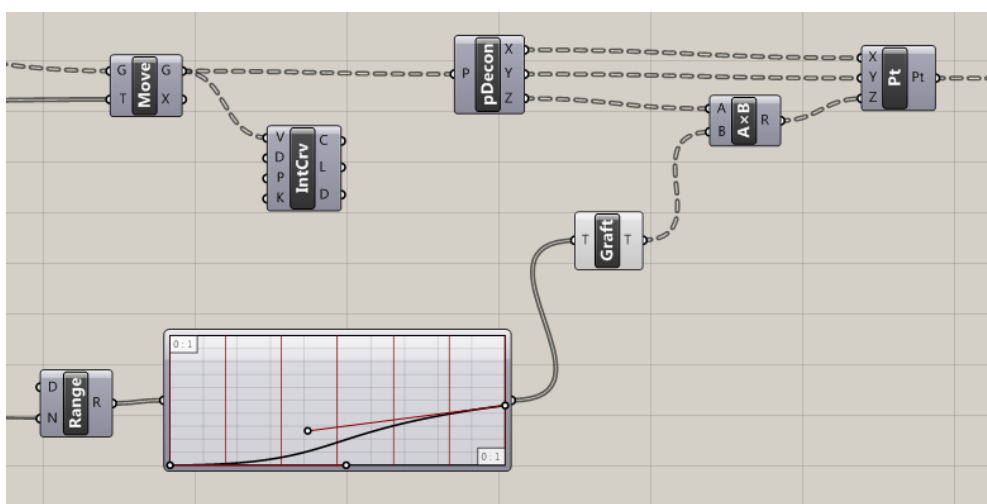


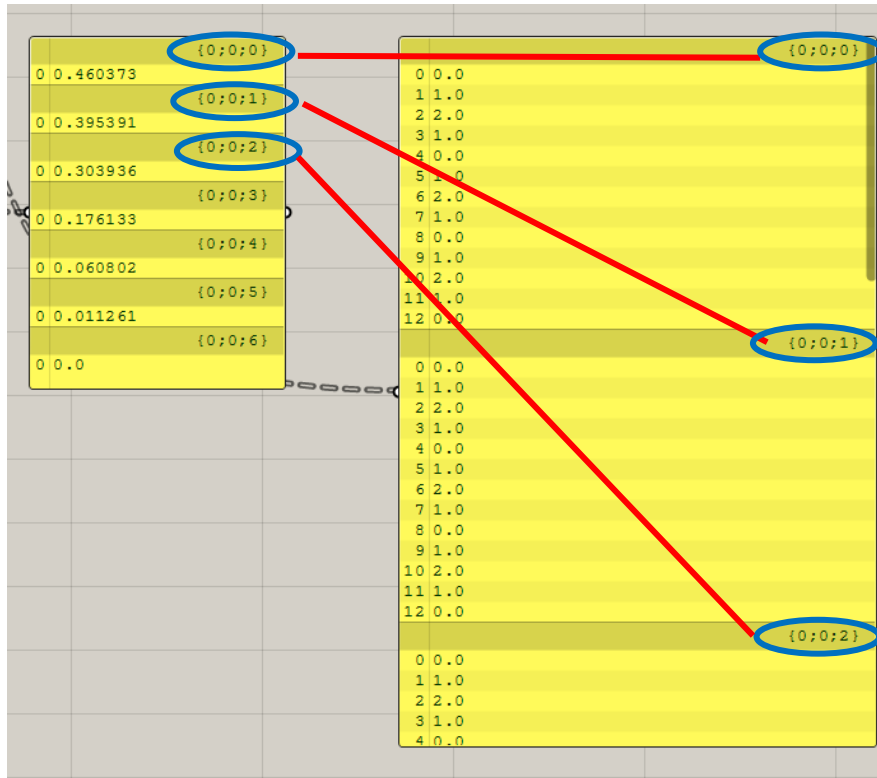
Be sure to create a list of vector whose length matches the number of points in each arc (f. ex: 13 points → 13 vectors). Moreover, make sure that the vector list length varies if the number of points in the arcs is changed.





- 6- To create the characteristic museum decreasing beam height, we should multiply the z coordinate of the beams with decreasing factors from the inner to the outer beams. Because the points in each arc are stored in a different branch, in order to associate each branch with the corresponding factor, factors should also be organized in branches. To store each factor into a different branch use a **graft** component. Factors will be used to multiply the points z coordinates contained in a branch with the same path. Factors in path {0;0;0} will multiply the points z coordinates in branch of path {0;0;0}
- 7- To multiply the z coordinates values with the factors, use a Point deconstruct to extract the z coordinates values, and a point construct to recreate the points from the original x y coordinates and the modified z coordinates values. It is recommended to use a graph mapper component to generate the factors. As a check, make sure that the parametric definition remains correct when you change the number of arcs and the number of points in the arcs





- 8- Create the beams geometry from the points with an Interpolate curve component. Flatten (sets>tree>flatten tree) and loft (surface>freeform) to create a surface between the beams.
- 9- Use curvature and curvature graph (Curve>analysis) to analyse beams curvature in characteristic points.
- 10- Can you find alternative methods to create the pattern? In case of affirmative answer pinpoint the advantages and limits of alternative methods. F. ex, could you simplify/reduce the number of components used?
- 11- **Optional:** can you design a similar museum geometry by using NURBS curves instead than a curve based on cosine function? You can restart from step 5 and design a different grasshopper definition for this purpose.