Computational Fabrication

CS 491 and 591
Professor: Leah Buechley
https://handandmachine.cs.unm.edu/classes/Computational_Fabrication_Spring2021/

Weekly Designers: Emerging Objects
Virginia San Fratello & Ronald Rael

https://www.rael-sanfratello.com/
http://emergingobjects.com/

Rael San Fratello

The Cabin of 3D Printed Curiosities demonstrates that 3D printing can be beautiful, meaningful, and well crafted – not crude, fast and cheap.

Rael San Fratello

Rael San Fratello

https://www.instagram.com/p/CyCTaWrP9ig/?img_index=1

Large Assignment 4: G-Code

Due on Halloween (Tuesday October 31)

Create three objects by generating gcode

https://handandmachine.org/classes/computational_fabrication/2023/10/19/gcode/

questions?

Today: Slicers

We're going to code a simple slicer from scratch

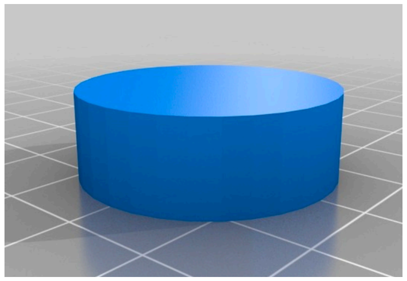
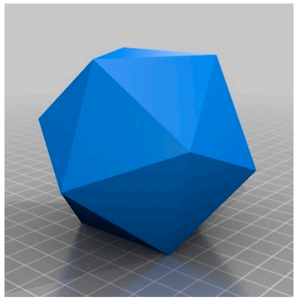
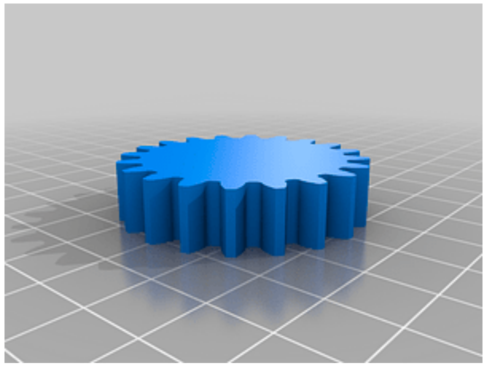
Slicer

- Takes an arbitrary geometry/shape as input
- Generates a toolpath (.gcode file) that will 3D print the shape
- Steps:
  - Slice shape into horizontal layers
  - For each layer, generate a toolpath
  - Toolpath for a layer may include walls, infill, and support

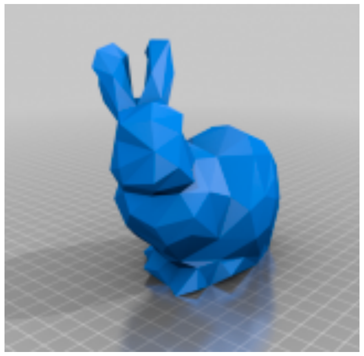
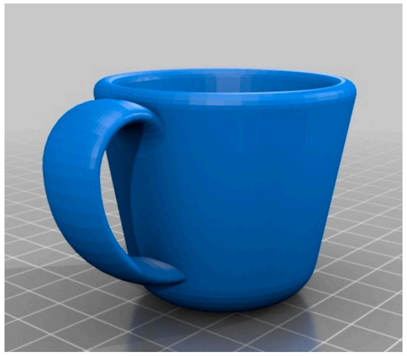
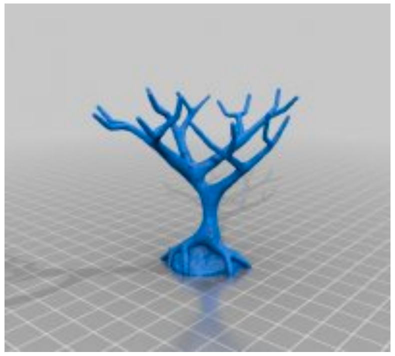
What We’ll Build: Simplest Slicer

- Generates a toolpath (.gcode file) that will traverse the outside wall of simple solids.
- Limitations on input shapes
  - Simple topology (no holes)
  - Simple geometry: each slice of shape must be a single surface
- Steps:
  - Slice shape into horizontal layers
  - For each layer, generate a toolpath that follows the outside curve of the shape

What We'll Build: Simplest Slicer

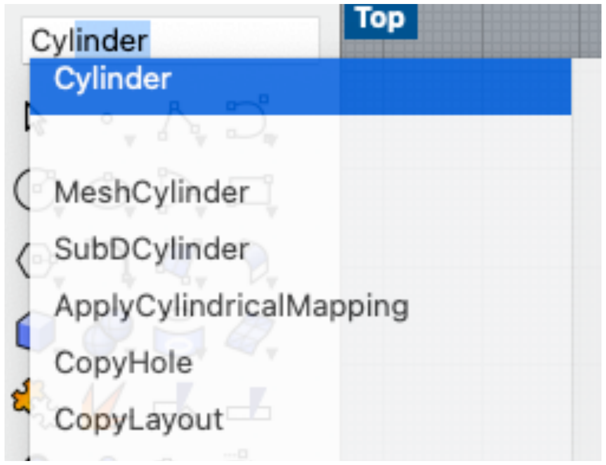
can slice

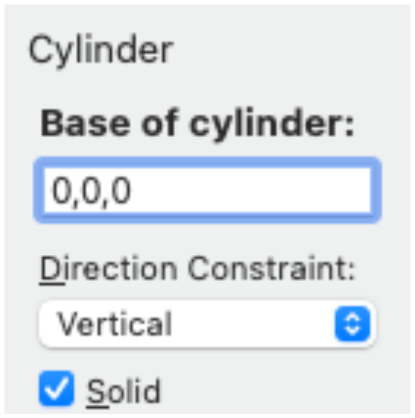




can't slice

questions?

Open up Rhino and Create a Cylinder

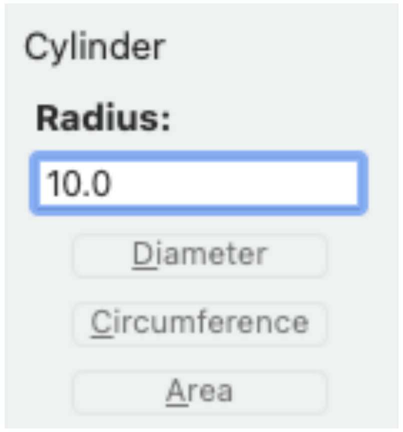



Cylinder

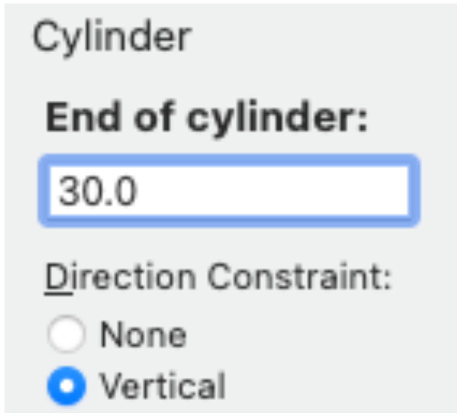
Base of cylinder: 0,0,0

Direction Constraint: Vertical

[✓] Solid


Cylinder

Radius: 10.0


Cylinder

End of cylinder: 30.0

Direction Constraint: None [✓ Vertical]

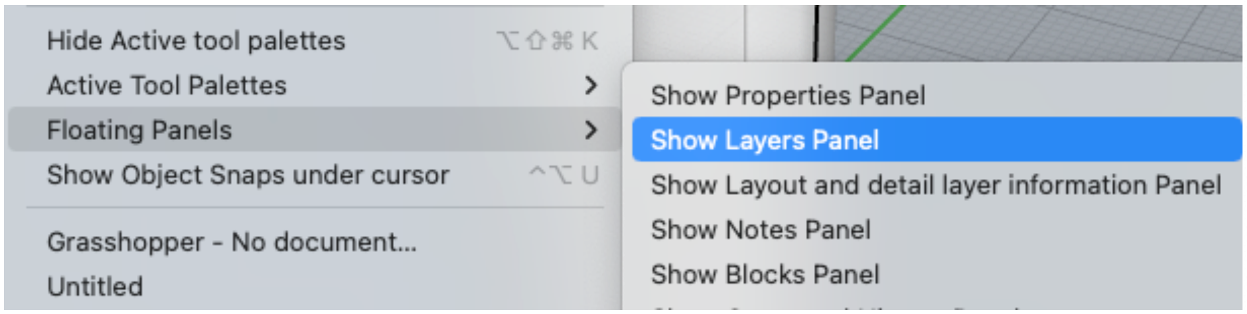
type Cylinder
into command line

Base at:
(0,0,0)

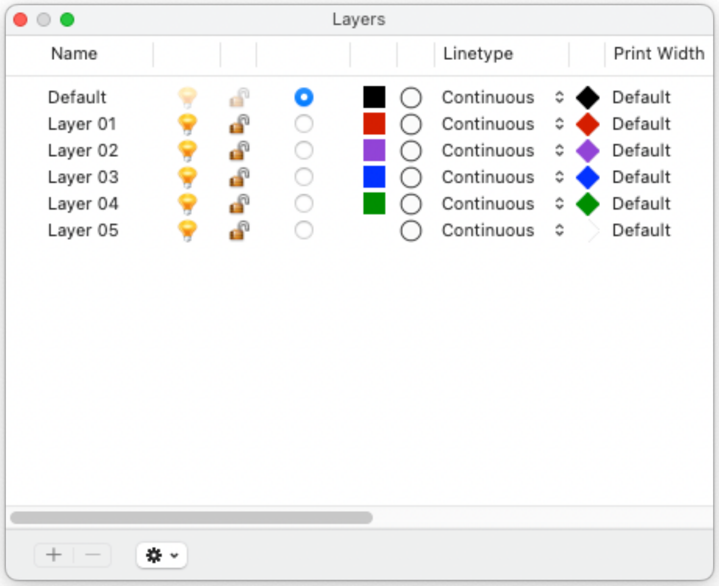
Radius = 10

Height = 30

Open the Layers Panel

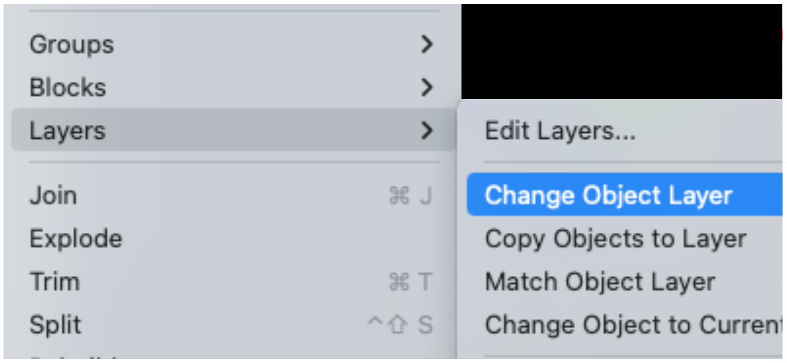

Hide Active tool palettes ⌥⇧⌘K
Active Tool Palettes
Floating Panels
Show Object Snaps under cursor ^⌥U
Grasshopper - No document...
Untitled
Show Properties Panel
Show Layers Panel
Show Layout and detail layer information Panel
Show Notes Panel
Show Blocks Panel

Window—>Floating Panels—>Show Layers Panel


Layers

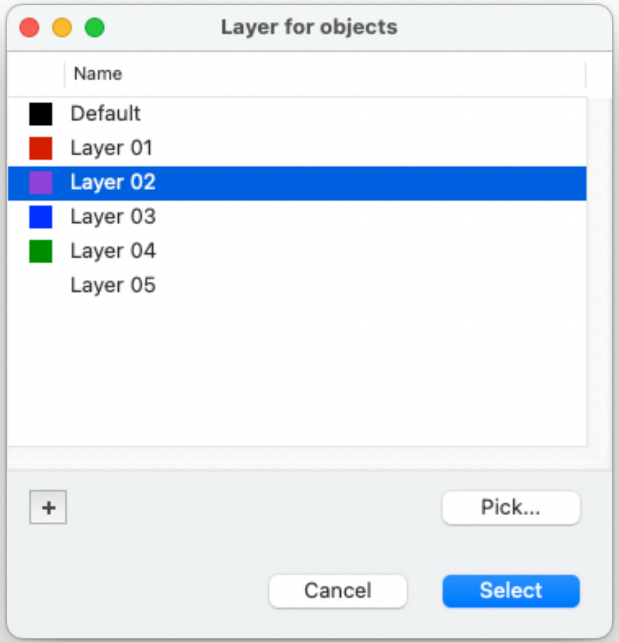
Name					Linetype	Print Width
Default			●	⬛	Continuous	Default
Layer 01				🟥	Continuous	Default
Layer 02				🟪	Continuous	Default
Layer 03				🟦	Continuous	Default
Layer 04				🟩	Continuous	Default
Layer 05					Continuous	Default

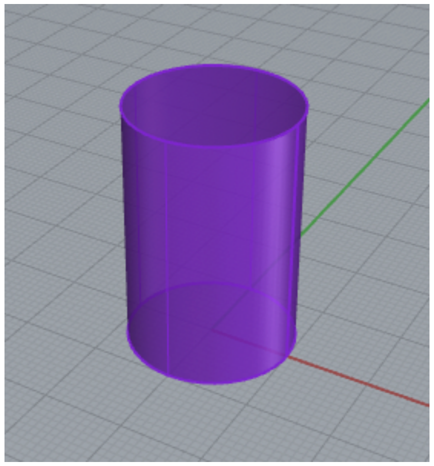
Move your Cylinder to Layer 2



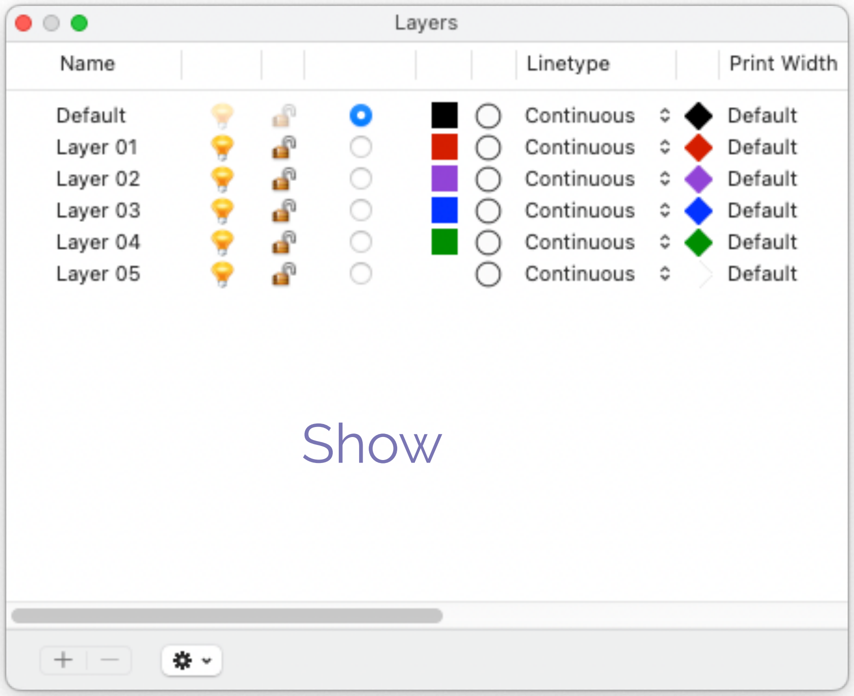
Select Object, then go to:

Edit—>Layers—>Change Object Layer

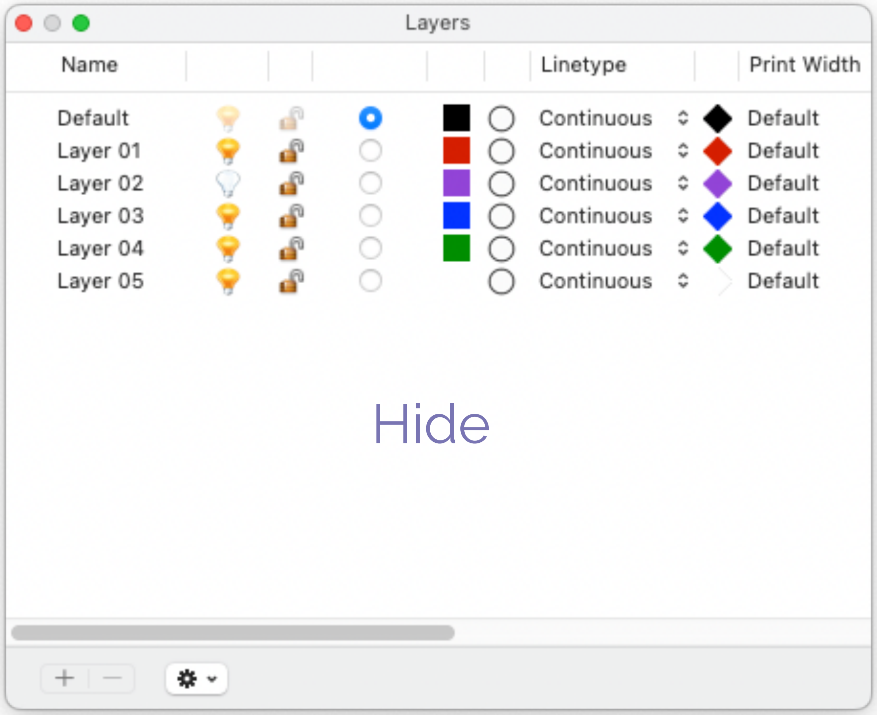




Show & hide layer w/ light bulb



Name						Linetype			Print Width
Default	💡	🔓	●	⬛	○	Continuous	⇕	◆	Default
Layer 01	💡	🔓	○	🟥	○	Continuous	⇕	◆	Default
Layer 02	💡	🔓	○	🟪	○	Continuous	⇕	◆	Default
Layer 03	💡	🔓	○	🟦	○	Continuous	⇕	◆	Default
Layer 04	💡	🔓	○	🟩	○	Continuous	⇕	◆	Default
Layer 05	💡	🔓	○		○	Continuous	⇕		Default

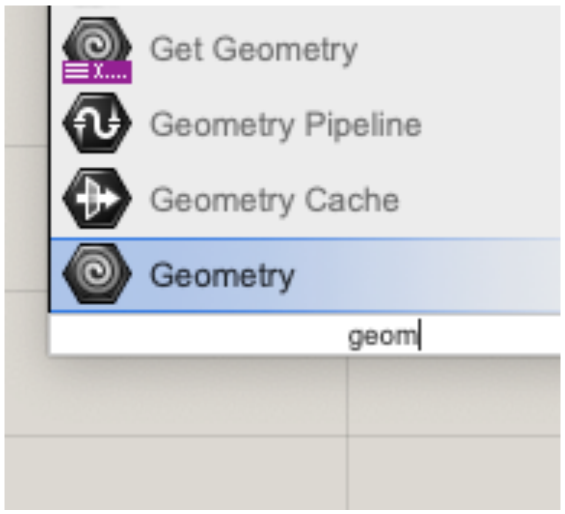


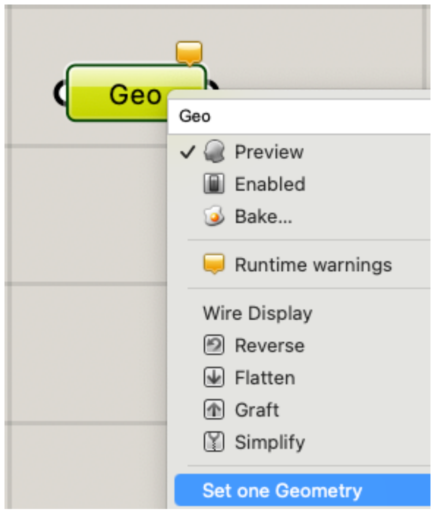
Name						Linetype			Print Width
Default	💡	🔓	●	⬛	○	Continuous	⇕	◆	Default
Layer 01	💡	🔓	○	🟥	○	Continuous	⇕	◆	Default
Layer 02	◌	🔓	○	🟪	○	Continuous	⇕	◆	Default
Layer 03	💡	🔓	○	🟦	○	Continuous	⇕	◆	Default
Layer 04	💡	🔓	○	🟩	○	Continuous	⇕	◆	Default
Layer 05	💡	🔓	○		○	Continuous	⇕		Default

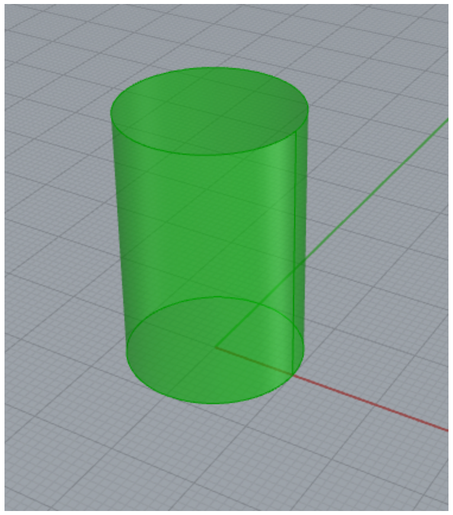
questions?

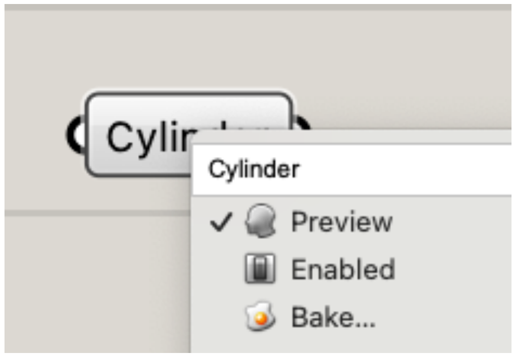
Open Grasshopper

Associate Cylinder w/ a Geometry







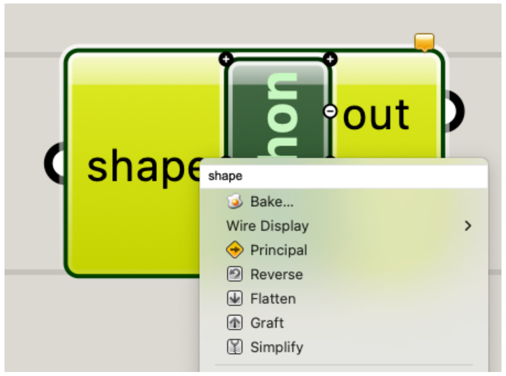


Right click on Geo block to rename

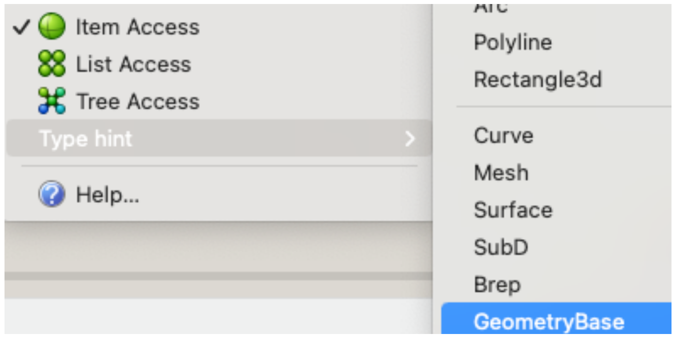
Code Overview

1. Get the height of the shape using BoundingBox.
2. Slice shape using AddSrfCountorCurves. This function outputs a list of edge curves.
3. Break each edge curve into a list of points using DivideCurve.
4. Follow this list of points with a turtle using set_position_point.

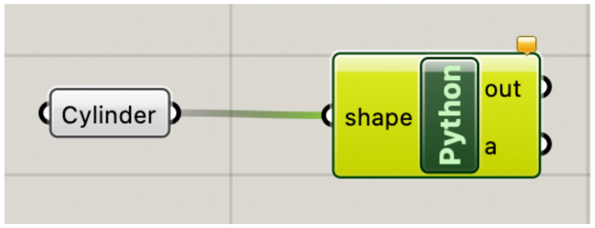
Implementation



Python block with one input, name it shape



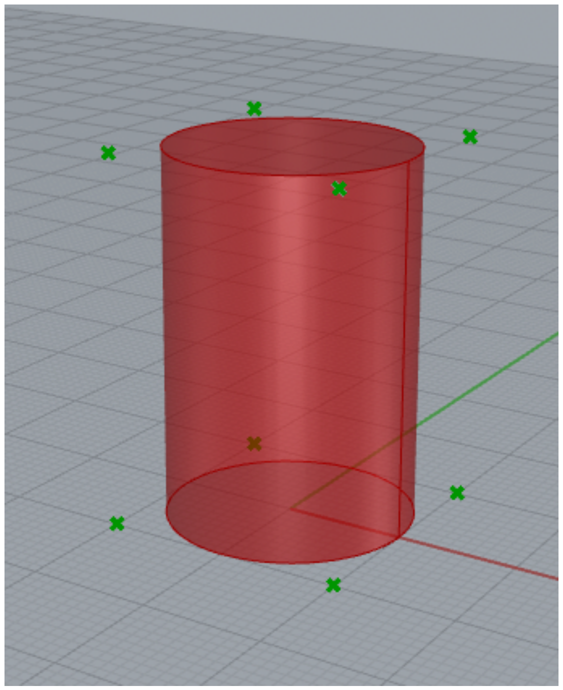
Type hint —> GeometryBase



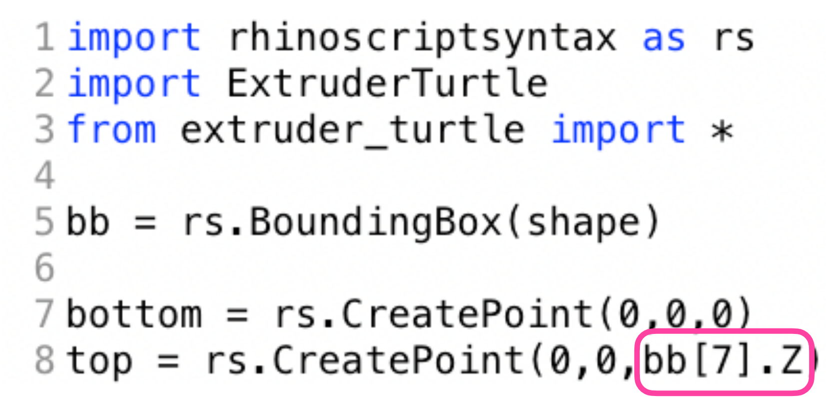
BoundingBox(shape)

```
import rhinoscriptsyntax as rs
import ExtruderTurtle
from extruder_turtle import *

bb = rs.BoundingBox(shape)
```

returns a list of 8 points that define a bounding box

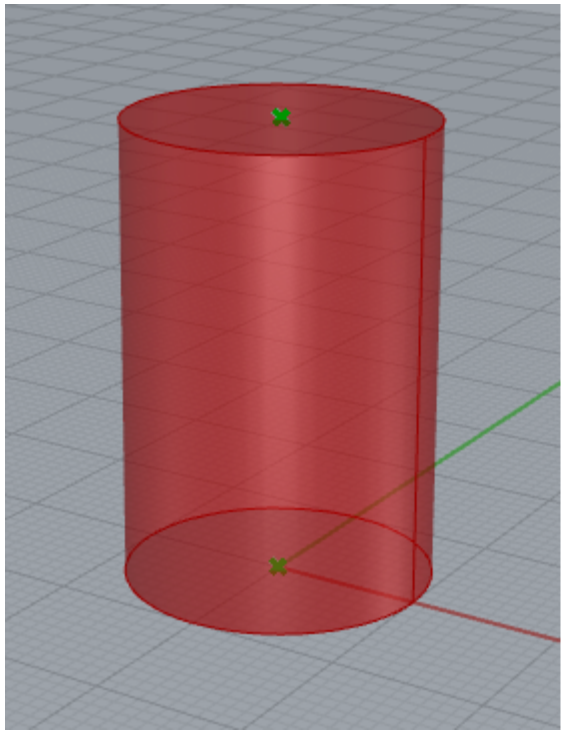


Get top and bottom points of shape



```python
import rhinoscriptsyntax as rs
import ExtruderTurtle
from extruder_turtle import *

bb = rs.BoundingBox(shape)

bottom = rs.CreatePoint(0,0,0)
top = rs.CreatePoint(0,0,bb[7].Z)
```

use Bounding Box to find Z coordinate of top point

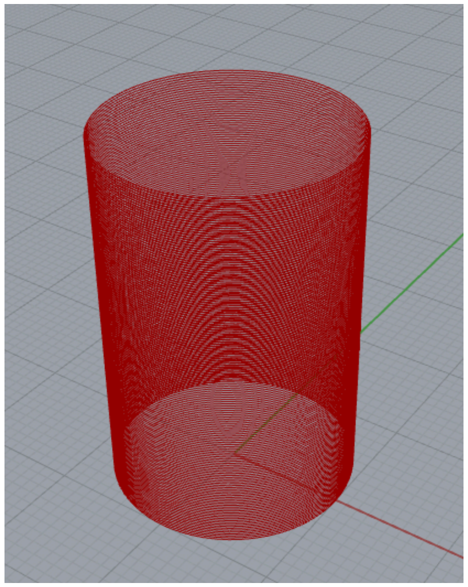


Set up Turtle

```python
import rhinoscriptsyntax as rs
import ExtruderTurtle
from extruder_turtle import *

bb = rs.BoundingBox(shape)

bottom = rs.CreatePoint(0,0,0)
top = rs.CreatePoint(0,0,bb[7].Z)

t = ExtruderTurtle()
t.setup(printer="ender")
layer_height = t.get_layer_height()

slices = rs.AddSrfContourCrvs(shape,(bottom,top),layer_height)
```

Slice shape!

```python
import rhinoscriptsyntax as rs
import ExtruderTurtle
from extruder_turtle import *

bb = rs.BoundingBox(shape)

bottom = rs.CreatePoint(0,0,0)
top = rs.CreatePoint(0,0,bb[7].Z)

t = ExtruderTurtle()
t.setup(printer="ender")
layer_height = t.get_layer_height()

slices = rs.AddSrfContourCrvs(shape,(bottom,top),layer_height)
```

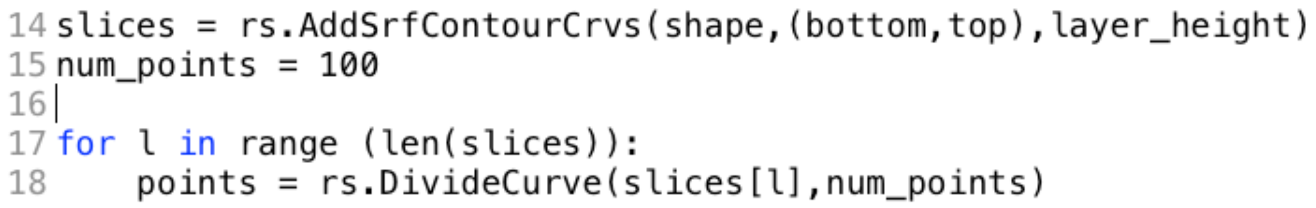


AddSrfCountourCrvs outputs a list of curves from bottom to top at intervals of layer_height

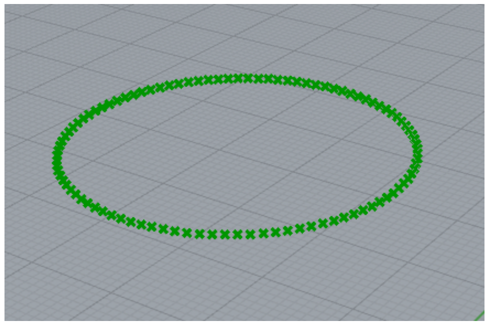
questions?

Now we’ll create a Turtle path

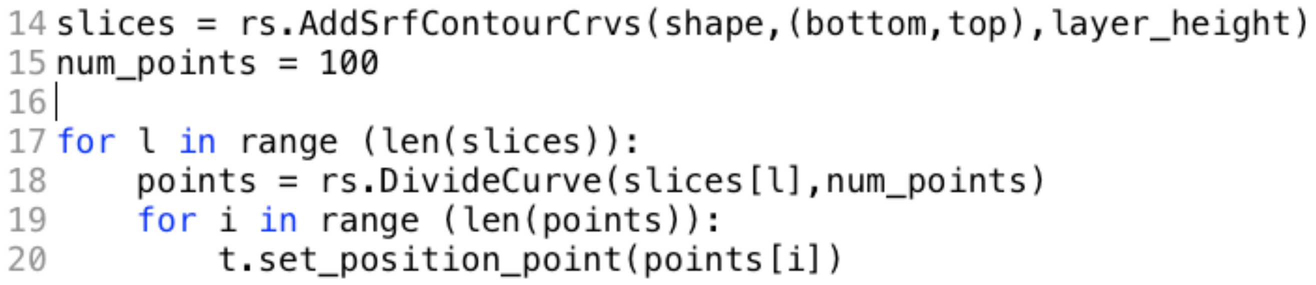
DivideCurve: break each curve into a list of points



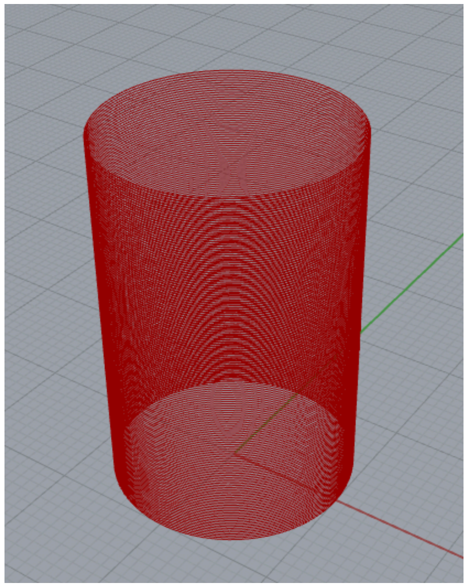
```python
slices = rs.AddSrfContourCrvs(shape,(bottom,top),layer_height)
num_points = 100

for l in range (len(slices)):
    points = rs.DivideCurve(slices[l],num_points)
```



Follow points with turtle

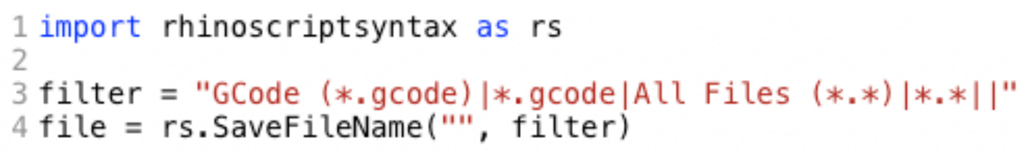


```
slices = rs.AddSrfContourCrvs(shape,(bottom,top),layer_height)
num_points = 100

for l in range (len(slices)):
    points = rs.DivideCurve(slices[l],num_points)
    for i in range (len(points)):
        t.set_position_point(points[i])
```

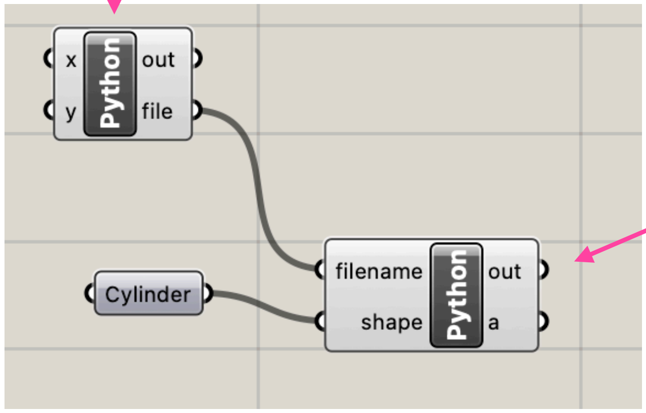


questions?

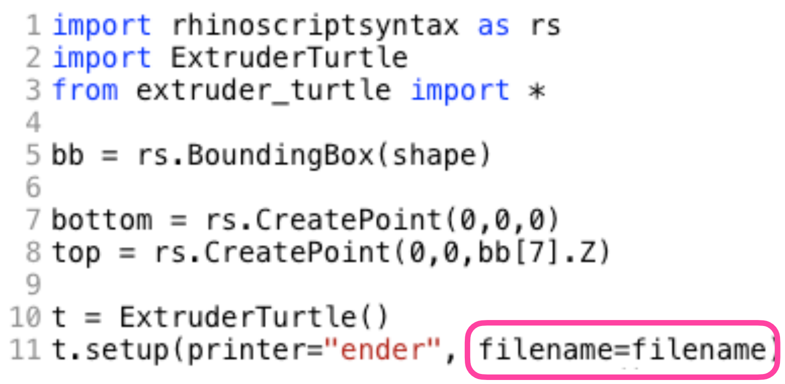
Add file generation to code



```python
import rhinoscriptsyntax as rs

filter = "GCode (*.gcode)|*.gcode|All Files (*.*)|*.*||"
file = rs.SaveFileName("", filter)
```

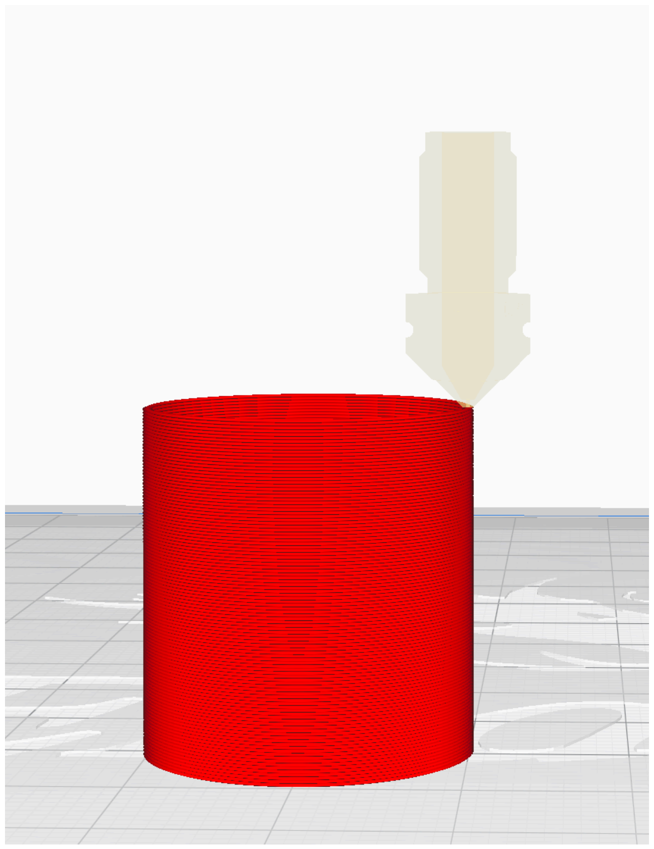


Type Hint for filename should be str



```python
import rhinoscriptsyntax as rs
import ExtruderTurtle
from extruder_turtle import *

bb = rs.BoundingBox(shape)

bottom = rs.CreatePoint(0,0,0)
top = rs.CreatePoint(0,0,bb[7].Z)

t = ExtruderTurtle()
t.setup(printer="ender", filename=filename)
```

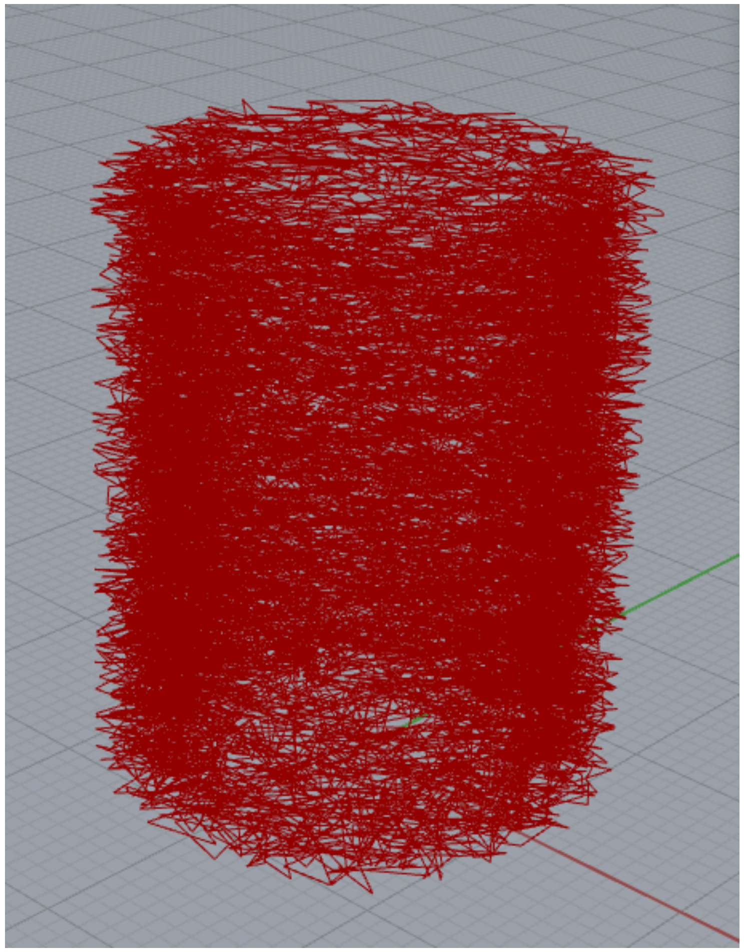
Preview in Cura



Now, for the fun part!

How can we make this slicer interesting?

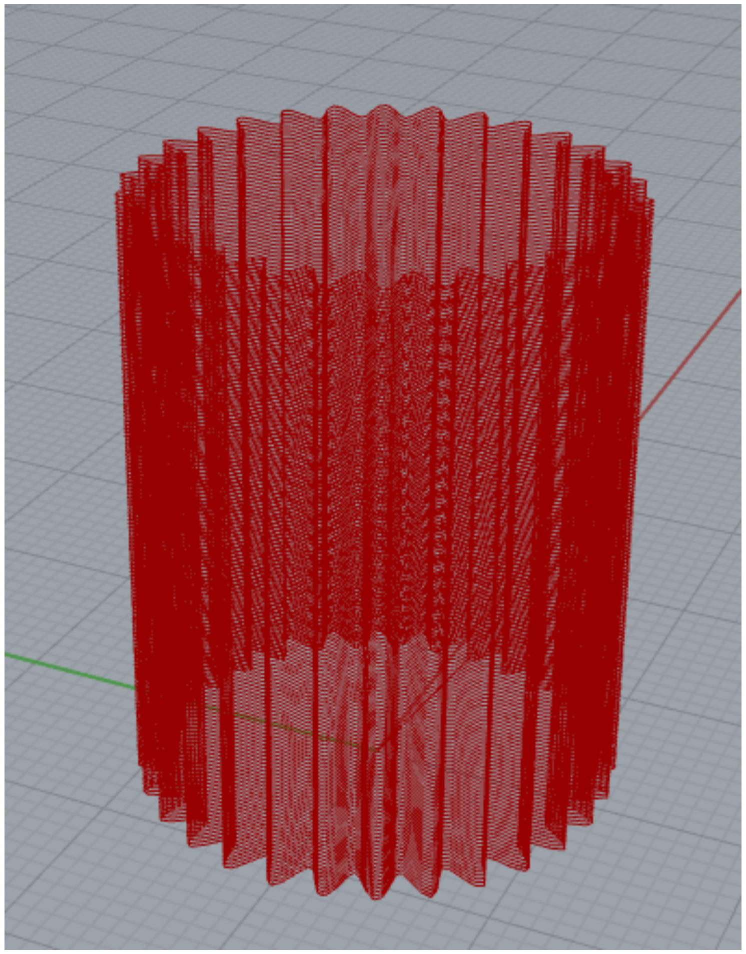
A little randomness



The magic of multiple Turtles

- Use one turtle to generate interesting points that are based on the slice curve for each layer. This turtle might generate a bunch of extraneous lines that you don't want to include in your print
- Use a second (primary) turtle to follow only the points that you want to include in your toolpath.

example: oscillating path

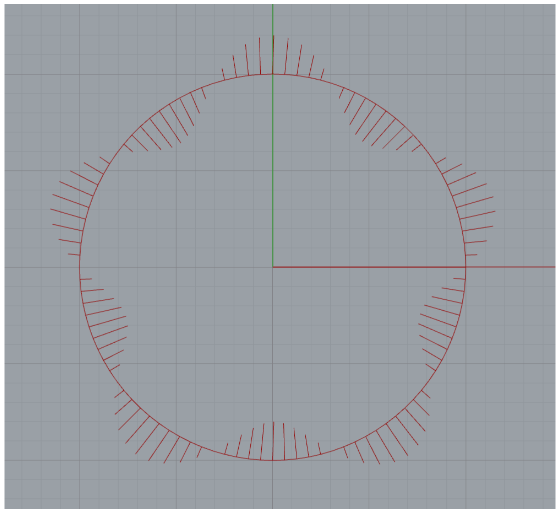


Two turtle example code

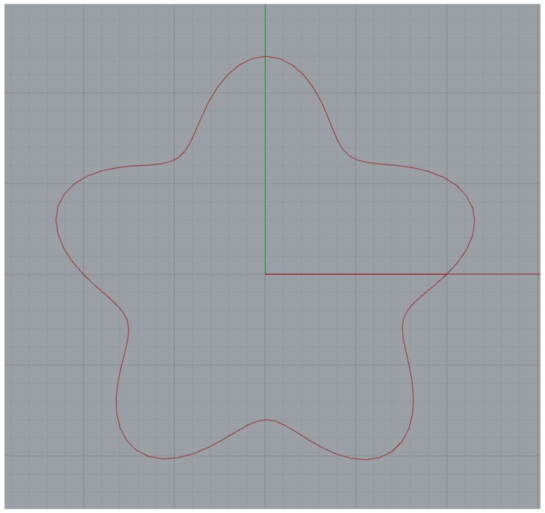
```python
slices = rs.AddSrfContourCrvs(shape,(bottom,top),layer_height)

num_points = 100
amplitude = 2.0
num_oscillations = 5
for l in range (len(slices)):
    points = rs.DivideCurve(slices[l],num_points)
    for i in range (len(points)):
        x0 = points[i].X
        y0 = points[i].Y
        z0 = points[i].Z
        t2.set_position(x0,y0,z0)
        theta = 360.0/num_points*i
        delta = amplitude * math.sin(num_oscillations*math.radians(theta))
        t2.right(90)
        t2.forward(delta)
        x = t2.getX()
        y = t2.getY()
        z = t2.getZ()
        t2.back(delta)
        t2.left(90)
        t.set_position(x,y,z)
```

Output

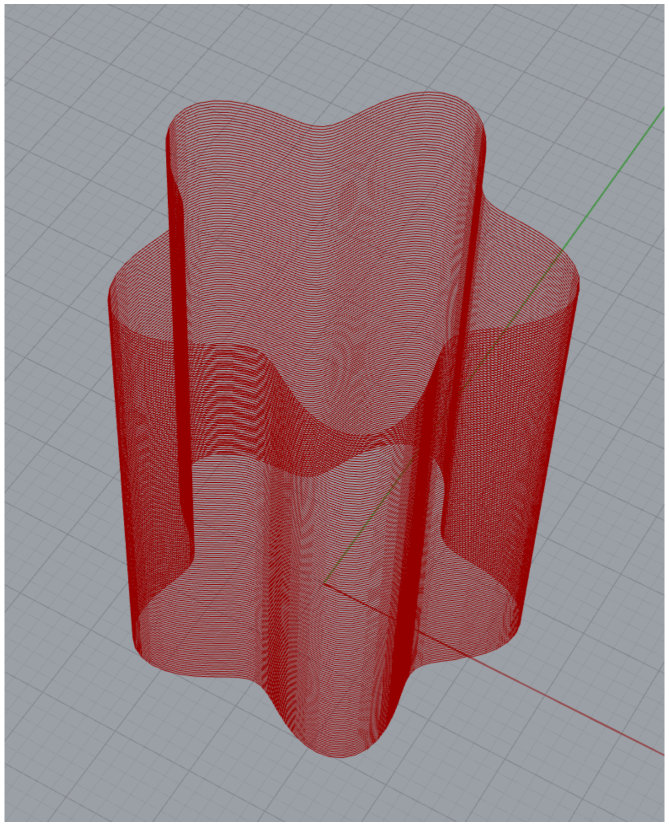
top view



t2 path



t path



t path

questions?

Thank you!

CS 491 and 591
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