

The gcodepreview PythonSCAD library*

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Abstract

The gcodepreview library allows using PythonSCAD (OpenPythonSCAD) to move a tool in lines and arcs and output DXF and G-code files so as to work as a CAD/CAM program for CNC.

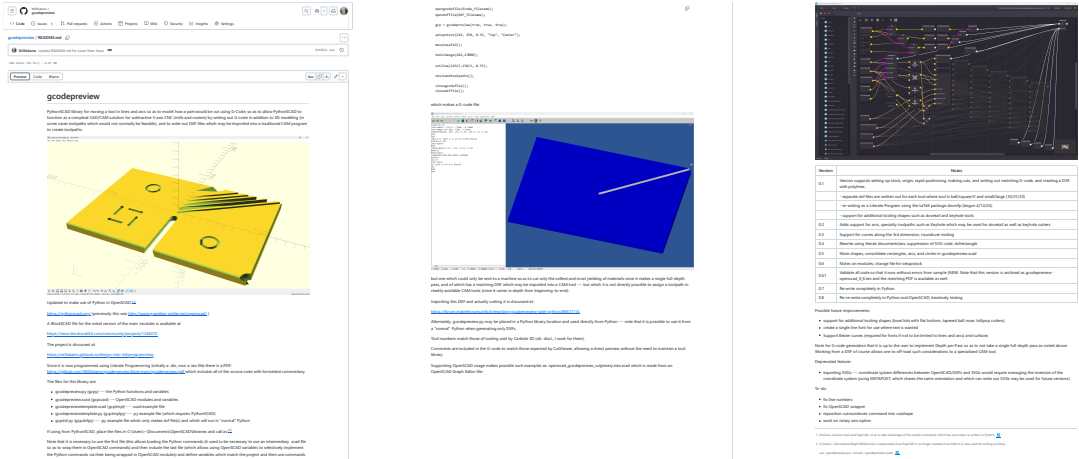
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*This file (gcodepreview) has version number vo.9, last revised 2025/07/4.

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1 **readme.md**



```
1 rdme # gcodepreview
2 rdme
3 rdme PythonSCAD library for moving a tool in lines and arcs so as to
  model how a part would be cut using G-Code, so as to allow
  PythonSCAD to function as a compleat CAD/CAM solution for
  subtractive 3-axis CNC (mills or routers at this time, 4th-axis
  support may come in a future version) by writing out G-code in
  addition to 3D modeling (in certain cases toolpaths which would
  not normally be feasible), and to write out DXF files which may
  be imported into a traditional CAM program to create toolpaths.
4 rdme
5 rdme ![OpenSCAD gcodepreview Unit Tests](https://raw.githubusercontent.com/WillAdams/gcodepreview/main/gcodepreviewtemplate.png?raw=true)
6 rdme
7 rdme Updated to make use of Python in OpenSCAD:[~rapcad]
8 rdme
9 rdme [~rapcad]: Previous versions had used RapCAD, so as to take
  advantage of the writeln command, which has since been re-
  written in Python.
10 rdme
11 rdme https://pythonscad.org/ (previously this was http://www.guenther-sohler.net/openscad/ )
12 rdme
13 rdme A BlockSCAD file for the initial version of the
14 rdme main modules is available at:
15 rdme
16 rdme https://www.blockscad3d.com/community/projects/1244473
17 rdme
18 rdme The project is discussed at:
19 rdme
20 rdme https://willadams.gitbook.io/design-into-3d/programming
21 rdme
22 rdme Since it is now programmed using Literate Programming (initially a
  .dtx, now a .tex file) there is a PDF: https://github.com/WillAdams/gcodepreview/blob/main/gcodepreview.pdf which includes
  all of the source code with formatted comments.
23 rdme
24 rdme The files for this library are:
25 rdme
26 rdme - gcodepreview.py (gcpy) --- the Python class/functions and
  variables
27 rdme - gcodepreview.scad (gcpscad) --- OpenSCAD modules and parameters
28 rdme
29 rdme And there several sample/template files which may be used as the
  starting point for a given project:
30 rdme
31 rdme - gcodepreviewtemplate.scad (gcptmpl) --- .scad example file
32 rdme - gcodepreviewtemplate.py (gcptmplpy) --- .py example file
33 rdme - gcpdxf.py (gcpdxfpy) --- .py example file which only makes dxf
  file(s) and which will run in "normal" Python in addition to
  PythonSCAD
34 rdme - gcpgc.py (gcpgc) --- .py example which loads a G-code file and
  generates a 3D preview showing how the G-code will cut
35 rdme
36 rdme If using from PythonSCAD, place the files in C:\Users\\~\Documents
  \OpenSCAD\libraries [~libraries] or, load them from Github using
  the command:
```

```

37 rdme
38 rdme     nimport("https://raw.githubusercontent.com/WillAdams/
           gcodepreview/refs/heads/main/gcodepreview.py")
39 rdme
40 rdme [^libraries]: C:\Users\\-\Documents\RapCAD\libraries is deprecated
           since RapCAD is no longer needed since Python is now used for
           writing out files.
41 rdme
42 rdme If using gcodepreview.scad call as:
43 rdme
44 rdme     use <gcodepreview.py>
45 rdme     include <gcodepreview.scad>
46 rdme
47 rdme Note that it is necessary to use the first file (this allows
           loading the Python commands and then include the last file (
           which allows using OpenSCAD variables to selectively implement
           the Python commands via their being wrapped in OpenSCAD modules)
           and define variables which match the project and then use
           commands such as:
48 rdme
49 rdme    .opengcodefile(Gcode_filename);
50 rdme    .opendxffile(DXF_filename);
51 rdme
52 rdme     gcp = gcodepreview(true, true);
53 rdme
54 rdme     setupstock(219, 150, 8.35, "Top", "Center");
55 rdme
56 rdme     movetosafeZ();
57 rdme
58 rdme     toolchange(102, 17000);
59 rdme
60 rdme     cutline(219/2, 150/2, -8.35);
61 rdme
62 rdme     stockandtoolpaths();
63 rdme
64 rdme     closegcodefile();
65 rdme     closedxfile();
66 rdme
67 rdme which makes a G-code file:
68 rdme
69 rdme ![OpenSCAD template G-code file](https://raw.githubusercontent.com/
           WillAdams/gcodepreview/main/gcodepreview_template.png?raw=true)
70 rdme
71 rdme but one which could only be sent to a machine so as to cut only the
           softest and most yielding of materials since it makes a single
           full-depth pass, and which has a matching DXF which may be
           imported into a CAM tool --- but which it is not directly
           possible to assign a toolpath in readily available CAM tools (
           since it varies in depth from beginning-to-end which is not
           included in the DXF since few tools make use of that information
           ).
72 rdme
73 rdme Importing this DXF and actually cutting it is discussed at:
74 rdme
75 rdme https://forum.makerforums.info/t/rewriting-gcodepreview-with-python
           /88617/14
76 rdme
77 rdme Alternately, gcodepreview.py may be placed in a Python library
           location and used directly from Python --- note that it is
           possible to use it from a "normal" Python when generating only
           DXFs as shown in gcpxdf.py.
78 rdme
79 rdme In the current version, tool numbers may match those of tooling
           sold by Carbide 3D (ob. discl., I work for them) and other
           vendors, or, a vendor-neutral system may be used.
80 rdme
81 rdme Comments are included in the G-code to match those expected by
           CutViewer, allowing a direct preview without the need to
           maintain a tool library (for such tooling as that program
           supports).
82 rdme
83 rdme Supporting OpenSCAD usage makes possible such examples as:
           openscad_gcodepreview_cutjoinery.tres.scad which is made from an
           OpenSCAD Graph Editor file:
84 rdme
85 rdme ![OpenSCAD Graph Editor Cut Joinery File](https://raw.
           githubusercontent.com/WillAdams/gcodepreview/main/
           OSGE_cutjoinery.png?raw=true)

```

```

86 rdme
87 rdme | Version          | Notes          |
88 rdme | ----- | ----- |
89 rdme | 0.1          | Version supports setting up stock, origin, rapid
           positioning, making cuts, and writing out matching G-code, and
           creating a DXF with polylines. |
90 rdme |              | - separate dxf files are written out for each
           tool where tool is ball/square/V and small/large (10/31/23)

           |
91 rdme |              | - re-writing as a Literate Program using the
           LaTeX package docmfp (begun 4/12/24)

           |
92 rdme |              | - support for additional tooling shapes such as
           dovetail and keyhole tools

           |
93 rdme | 0.2          | Adds support for arcs, specialty toolpaths such
           as Keyhole which may be used for dovetail as well as keyhole
           cutters

           |
94 rdme | 0.3          | Support for curves along the 3rd dimension,
           roundover tooling

           |
95 rdme | 0.4          | Rewrite using literati documentclass, suppression
           of SVG code, dxfrextangle

           |
96 rdme | 0.5          | More shapes, consolidate rectangles, arcs, and
           circles in gcodepreview.scad

           |
97 rdme | 0.6          | Notes on modules, change file for setupstock

           |
98 rdme | 0.61         | Validate all code so that it runs without errors
           from sample (NEW: Note that this version is archived as
           gcodepreview-openscad_0_6.tex and the matching PDF is available
           as well) |
99 rdme | 0.7          | Re-write completely in Python

           |
100 rdme | 0.8          | Re-re-write completely in Python and OpenSCAD,
           iteratively testing

           |
101 rdme | 0.801        | Add support for bowl bits with flat bottom

           |
102 rdme | 0.802        | Add support for tapered ball-nose and V tools
           with flat bottom

           |
103 rdme | 0.803        | Implement initial color support and joinery
           modules (dovetail and full blind box joint modules)

           |
104 rdme | 0.9          | Re-write to use Python lists for 3D shapes for
           toolpaths and rapids. |
105 rdme
106 rdme Possible future improvements:
107 rdme
108 rdme - support for post-processors
109 rdme - support for 4th-axis
110 rdme - support for two-sided machining (import an STL or other file to
           use for stock, or possibly preserve the state after one cut and
           then rotate the cut stock/part)
111 rdme - support for additional tooling shapes (lollipop cutters)
112 rdme - create a single line font for use where text is wanted
113 rdme - Support Bézier curves (required for fonts if not to be limited
           to lines and arcs) and surfaces
114 rdme
115 rdme Note for G-code generation that it is up to the user to implement
           Depth per Pass so as to not take a single full-depth pass as
           noted above. Working from a DXF of course allows one to off-load
           such considerations to a specialized CAM tool.

```

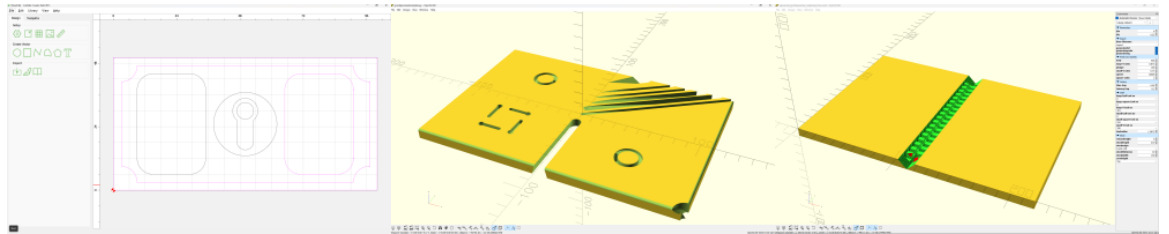
```
116 rdme
117 rdme To-do:
118 rdme
119 rdme - determine why one quadrant of arc command doesn't work in
        OpenSCAD
120 rdme - clock-wise arcs
121 rdme - add toolpath for cutting countersinks using ball-nose tool from
        inside working out
122 rdme - verify OpenSCAD wrapper and add any missing commands for Python
123 rdme - verify support for shaft on tooling
124 rdme - create a folder of template and sample files
125 rdme - clean up/comment out all mentions of previous versions/features/
        implementations/deprecated features
126 rdme - fully implement/verify describing/saving/loading tools using
        CutViewer comments
127 rdme
128 rdme Deprecated feature:
129 rdme
130 rdme - exporting SVGs --- coordinate system differences between
        OpenSCAD/DXFs and SVGs would require managing the inversion of
        the coordinate system (using METAPOST, which shares the same
        orientation and which can write out SVGs may be used for future
        versions)
```

2 Usage and Templates

The `gcodepreview` library allows the modeling of 2D geometry and 3D shapes using Python or by calling Python from within Open(Python)SCAD, enabling the creation of 2D DXFs, G-code (which cuts a 2D or 3D part), or 3D models as a preview of how the file will cut. These abilities may be accessed in “plain” Python (to make DXFs), or Python or OpenSCAD in PythonSCAD (to make DXFs, and/or G-code with 3D modeling) for a preview. Providing them in a programmatic context allows making parts or design elements of parts (e.g., joinery) which would be tedious or difficult (or verging on impossible) to draw by hand in a traditional CAD or vector drawing application. A further consideration is that this is “Design for Manufacture” taken to its ultimate extreme, and that a part so designed is inherently manufacturable (so long as the dimensions and radii allows for reasonable tool (and toolpath) geometries).

The various commands are shown all together in templates so as to provide examples of usage, and to ensure that the various files are used/included as necessary, all variables are set up with the correct names (note that the sparse template in `readme.md` eschews variables), and that if enabled, files are opened before being written to, and that each is closed at the end in the correct order. Note that while the template files seem overly verbose, they specifically incorporate variables for each tool shape, possibly in two different sizes, and a feed rate parameter or ratio for each, which may be used (by setting a tool #) or ignored (by leaving the variable for a given tool at zero (0)).

It should be that the `readme` at the project page which serves as an overview, and this section (which serves as a collection of templates and a tutorial) are all the documentation which most users will need (and arguably is still too much). The balance of the document after this section shows all the code and implementation details, and will where appropriate show examples of usage excerpted from the template files (serving as a how-to guide as well as documenting the code) as well as Indices (which serve as a front-end for reference).



Some comments on the templates:

- minimal — each is intended as a framework for a minimal working example (MWE) — it should be possible to comment out unused/unneeded portions and so arrive at code which tests any aspect of this project and which may be used as a starting point for a new part/project
- compleat — a quite wide variety of tools are listed (and probably more will be added in the future), but pre-defining them and having these “hooks” seems the easiest mechanism to handle the requirements of subtractive machining.
- shortcuts — as the various examples show, while in real life it is necessary to make many passes with a tool, an expedient shortcut is to forgo the `loop` operation and just use a `hull()` operation and avoid the requirement of implementing Depth per Pass (but note that this will lose the previewing of scalloped tool marks in places where they might appear otherwise)

One fundamental aspect of this tool is the question of *Layers of Abstraction* (as put forward by Dr. Donald Knuth as the crux of computer science) and *Problem Decomposition* (Prof. John Ousterhout’s answer to that question). To a great degree, the basic implementation of this tool will use G-code as a reference implementation, simultaneously using the abstraction from the mechanical task of machining which it affords as a decomposed version of that task, and creating what is in essence, both a front-end, and a tool, and an API for working with G-code programmatically. This then requires an architecture which allows 3D modeling (OpenSCAD), and writing out files (Python).

Further features will be added to the templates as they are created, and the main image updated to reflect the capabilities of the system.

2.1 `gcpdxf.py`

The most basic usage, with the fewest dependencies is to use “plain” Python to create `dxf` files. Note that this example includes an optional command `nimport(<URL>)` which if enabled/uncommented (and the following line commented out), will allow one to use OpenPythonSCAD to import the library from Github, sidestepping the need to download and install the library locally into an installation of OpenPythonSCAD. Usage in “normal” Python will require manually installing the `gcodepreview.py` file where Python can find it. A further consideration is where the file will be placed if the full path is not enumerated, the Desktop is the default destination for Microsoft Windows.

```

1 gcpdxfpy from openscad import *
2 gcpdxfpy # nimport("https://raw.githubusercontent.com/WillAdams/gcodepreview
    /refs/heads/main/gcodepreview.py")
3 gcpdxfpy from gcodepreview import *
4 gcpdxfpy
5 gcpdxfpy gcp = gcodepreview(False, # generategcode
6 gcpdxfpy                               True   # generatedxf
7 gcpdxfpy                               )
8 gcpdxfpy
9 gcpdxfpy # [Stock] */
10 gcpdxfpy stockXwidth = 100
11 gcpdxfpy # [Stock] */
12 gcpdxfpy stockYheight = 50
13 gcpdxfpy
14 gcpdxfpy # [Export] */
15 gcpdxfpy Base_filename = "gcpdxf"
16 gcpdxfpy
17 gcpdxfpy
18 gcpdxfpy # [CAM] */
19 gcpdxfpy large_square_tool_num = 102
20 gcpdxfpy # [CAM] */
21 gcpdxfpy small_square_tool_num = 0
22 gcpdxfpy # [CAM] */
23 gcpdxfpy large_ball_tool_num = 0
24 gcpdxfpy # [CAM] */
25 gcpdxfpy small_ball_tool_num = 0
26 gcpdxfpy # [CAM] */
27 gcpdxfpy large_V_tool_num = 0
28 gcpdxfpy # [CAM] */
29 gcpdxfpy small_V_tool_num = 0
30 gcpdxfpy # [CAM] */
31 gcpdxfpy DT_tool_num = 374
32 gcpdxfpy # [CAM] */
33 gcpdxfpy KH_tool_num = 0
34 gcpdxfpy # [CAM] */
35 gcpdxfpy Roundover_tool_num = 0
36 gcpdxfpy # [CAM] */
37 gcpdxfpy MISC_tool_num = 0
38 gcpdxfpy
39 gcpdxfpy # [Design] */
40 gcpdxfpy inset = 3
41 gcpdxfpy # [Design] */
42 gcpdxfpy radius = 6
43 gcpdxfpy # [Design] */
44 gcpdxfpy cornerstyle = "Fillet" # "Chamfer", "Flipped Fillet"
45 gcpdxfpy
46 gcpdxfpy gcp.opendxf(file(Base_filename))
47 gcpdxfpy
48 gcpdxfpy gcp.dxfrectangle(large_square_tool_num, 0, 0, stockXwidth,
    stockYheight)
49 gcpdxfpy
50 gcpdxfpy gcp.setdxfcolor("Red")
51 gcpdxfpy
52 gcpdxfpy gcp.dxfarc(large_square_tool_num, inset, inset, radius, 0, 90)
53 gcpdxfpy gcp.dxfarc(large_square_tool_num, stockXwidth - inset, inset,
    radius, 90, 180)
54 gcpdxfpy gcp.dxfarc(large_square_tool_num, stockXwidth - inset, stockYheight
    - inset, radius, 180, 270)
55 gcpdxfpy gcp.dxfarc(large_square_tool_num, inset, stockYheight - inset,
    radius, 270, 360)
56 gcpdxfpy
57 gcpdxfpy gcp.dxfline(large_square_tool_num, inset, inset + radius, inset,
    stockYheight - (inset + radius))
58 gcpdxfpy gcp.dxfline(large_square_tool_num, inset + radius, inset,
    stockXwidth - (inset + radius), inset)
59 gcpdxfpy gcp.dxfline(large_square_tool_num, stockXwidth - inset, inset +
    radius, stockXwidth - inset, stockYheight - (inset + radius))
60 gcpdxfpy gcp.dxfline(large_square_tool_num, inset + radius, stockYheight -
    inset, stockXwidth - (inset + radius), stockYheight - inset)
61 gcpdxfpy
62 gcpdxfpy gcp.setdxfcolor("Blue")
63 gcpdxfpy
64 gcpdxfpy gcp.dxfrectangle(large_square_tool_num, radius +inset, radius,
    stockXwidth/2 - (radius * 4), stockYheight - (radius * 2),
    cornerstyle, radius)
65 gcpdxfpy gcp.dxfrectangle(large_square_tool_num, stockXwidth/2 + (radius *
    2) + inset, radius, stockXwidth/2 - (radius * 4), stockYheight -
    (radius * 2), cornerstyle, radius)

```



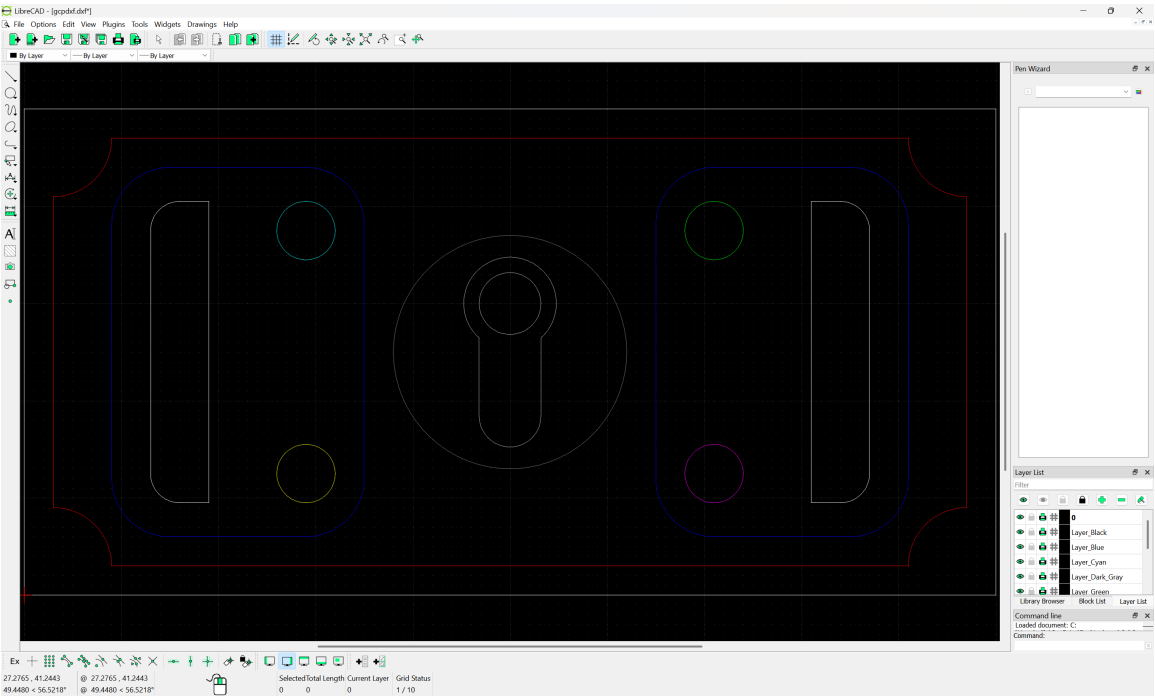
```

66 gcpdxfpyp
67 gcpdxfpyp gcp.setdxfc("Black")
68 gcpdxfpyp
69 gcpdxfpyp gcp.beginpolyline(large_square_tool_num)
70 gcpdxfpyp gcp.addvertex(large_square_tool_num, stockXwidth*0.75+radius*1.5,
    stockYheight/4-radius/2)
71 gcpdxfpyp gcp.addvertex(large_square_tool_num, stockXwidth*0.75+radius,
    stockYheight/4-radius/2)
72 gcpdxfpyp gcp.addvertex(large_square_tool_num, stockXwidth*0.75+radius,
    stockYheight*0.75+radius/2)
73 gcpdxfpyp gcp.addvertex(large_square_tool_num, stockXwidth*0.75+radius*1.5,
    stockYheight*0.75+radius/2)
74 gcpdxfpyp gcp.closepolyline(large_square_tool_num)
75 gcpdxfpyp
76 gcpdxfpyp gcp.dxfarc(large_square_tool_num, stockXwidth*0.75+radius*1.5,
    stockYheight*0.75, radius/2, 0, 90)
77 gcpdxfpyp
78 gcpdxfpyp gcp.beginpolyline(large_square_tool_num)
79 gcpdxfpyp gcp.addvertex(large_square_tool_num, stockXwidth*0.75+radius*2,
    stockYheight*0.75)
80 gcpdxfpyp gcp.addvertex(large_square_tool_num, stockXwidth*0.75+radius*2,
    stockYheight/4)
81 gcpdxfpyp gcp.closepolyline(large_square_tool_num)
82 gcpdxfpyp
83 gcpdxfpyp gcp.dxfarc(large_square_tool_num, stockXwidth*0.75+radius*1.5,
    stockYheight/4, radius/2, 270, 360)
84 gcpdxfpyp
85 gcpdxfpyp gcp.setdxfc("White")
86 gcpdxfpyp
87 gcpdxfpyp gcp.beginpolyline(large_square_tool_num)
88 gcpdxfpyp gcp.addvertex(large_square_tool_num, stockXwidth*0.25-radius*1.5,
    stockYheight/4-radius/2)
89 gcpdxfpyp gcp.addvertex(large_square_tool_num, stockXwidth*0.25-radius,
    stockYheight/4-radius/2)
90 gcpdxfpyp gcp.addvertex(large_square_tool_num, stockXwidth*0.25-radius,
    stockYheight*0.75+radius/2)
91 gcpdxfpyp gcp.addvertex(large_square_tool_num, stockXwidth*0.25-radius*1.5,
    stockYheight*0.75+radius/2)
92 gcpdxfpyp gcp.closepolyline(large_square_tool_num)
93 gcpdxfpyp
94 gcpdxfpyp gcp.dxfarc(large_square_tool_num, stockXwidth*0.25-radius*1.5,
    stockYheight*0.75, radius/2, 90, 180)
95 gcpdxfpyp
96 gcpdxfpyp gcp.beginpolyline(large_square_tool_num)
97 gcpdxfpyp gcp.addvertex(large_square_tool_num, stockXwidth*0.25-radius*2,
    stockYheight*0.75)
98 gcpdxfpyp gcp.addvertex(large_square_tool_num, stockXwidth*0.25-radius*2,
    stockYheight/4)
99 gcpdxfpyp gcp.closepolyline(large_square_tool_num)
100 gcpdxfpyp
101 gcpdxfpyp gcp.dxfarc(large_square_tool_num, stockXwidth*0.25-radius*1.5,
    stockYheight/4, radius/2, 180, 270)
102 gcpdxfpyp
103 gcpdxfpyp gcp.setdxfc("Yellow")
104 gcpdxfpyp gcp.dxfcircle(large_square_tool_num, stockXwidth/4+1+radius/2,
    stockYheight/4, radius/2)
105 gcpdxfpyp
106 gcpdxfpyp gcp.setdxfc("Green")
107 gcpdxfpyp gcp.dxfcircle(large_square_tool_num, stockXwidth*0.75-(1+radius/2),
    stockYheight*0.75, radius/2)
108 gcpdxfpyp
109 gcpdxfpyp gcp.setdxfc("Cyan")
110 gcpdxfpyp gcp.dxfcircle(large_square_tool_num, stockXwidth/4+1+radius/2,
    stockYheight*0.75, radius/2)
111 gcpdxfpyp
112 gcpdxfpyp gcp.setdxfc("Magenta")
113 gcpdxfpyp gcp.dxfcircle(large_square_tool_num, stockXwidth*0.75-(1+radius/2),
    stockYheight/4, radius/2)
114 gcpdxfpyp
115 gcpdxfpyp gcp.setdxfc("Dark_Gray")
116 gcpdxfpyp
117 gcpdxfpyp gcp.dxfcircle(large_square_tool_num, stockXwidth/2, stockYheight/2,
    radius * 2)
118 gcpdxfpyp
119 gcpdxfpyp gcp.setdxfc("Light_Gray")
120 gcpdxfpyp
121 gcpdxfpyp gcp.dxfKH(374, stockXwidth/2, stockYheight/5*3, 0, -7, 270,
    11.5875)

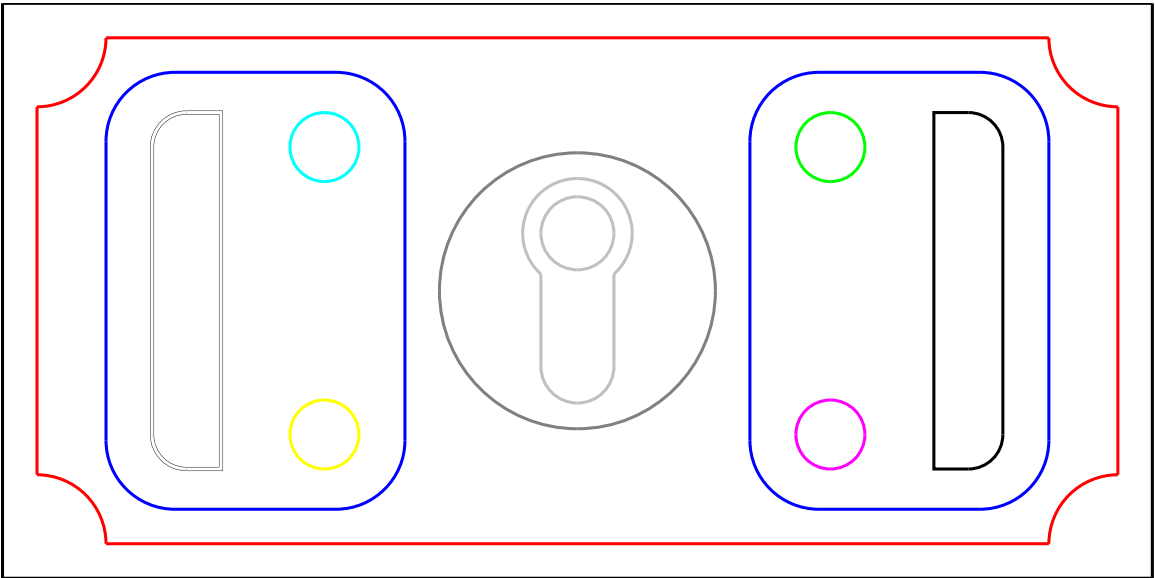
```

```
122 gcpdxfpyp
123 gcpdxfpyp gcp.closedxfile()
```

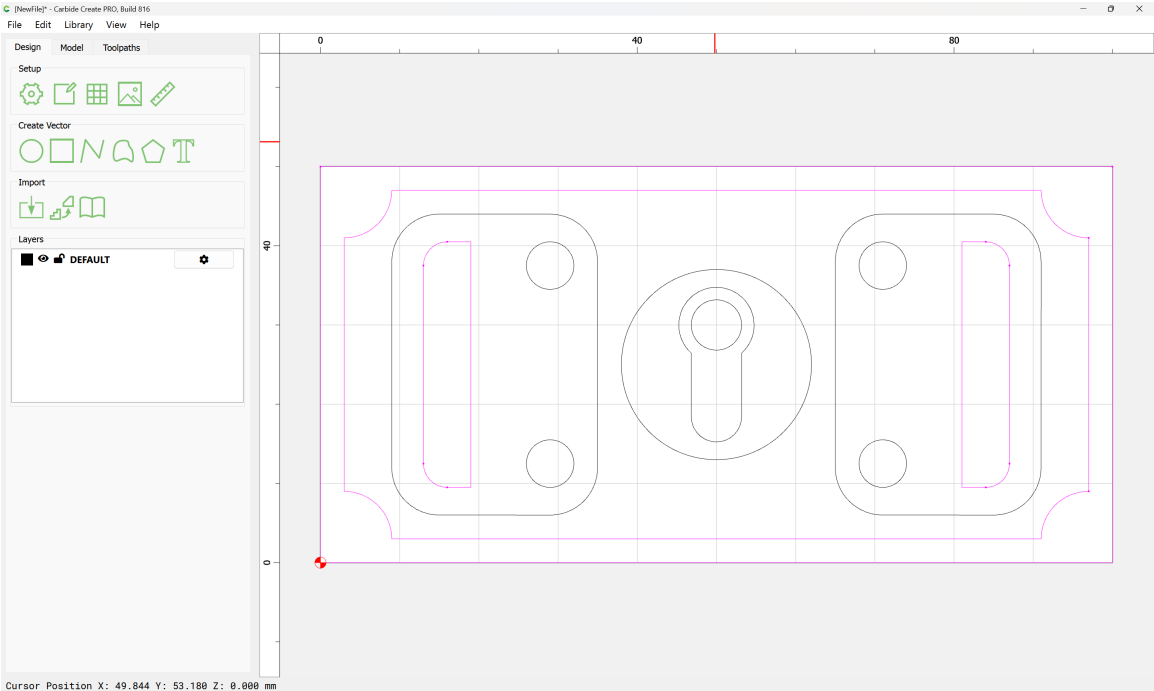
which creates a .dxf file which may be imported into any CAD program:



with the appearance (once converted into a .svg and then re-saved as a .pdf and edited so as to show the white elements):



and which may be imported into pretty much any CAD or CAM application, e.g., Carbide Create:



As shown/implied by the above code, the following commands/shapes are implemented:

- dxfrectangle (specify lower-left and upper-right corners)
 - dxfrectangleround (specified as “Fillet” and radius for the round option)
 - dxfrectanglechamfer (specified as “Chamfer” and radius for the round option)
 - dxfrectangleflippedfillet (specified as “Flipped Fillet” and radius for the option)
- dxfcircle (specifying their center and radius)
- dxfline (specifying begin/end points)
- dxfar (specifying arc center, radius, and beginning/ending angles)
- dxfkH (specifying origin, depth, angle, distance)

2.2 gcpcutdxf.py

A notable limitation of the above is that there is no interactivity — the .dxf file is generated, then must be opened and the result of the run checked (if there is a DXF viewer/editor which will live-reload the file based on it being updated that would be obviated). Reworking the commands for a simplified version of the above design so as to show a 3D model is a straight-forward task:

```
1 gcpcutdxfpy from openscad import *
2 gcpcutdxfpy # nimport("https://raw.githubusercontent.com/WillAdams/gcodepreview
    /refs/heads/main/gcodepreview.py")
3 gcpcutdxfpy from gcodepreview import *
4 gcpcutdxfpy
5 gcpcutdxfpy fa = 2
6 gcpcutdxfpy fs = 0.125
7 gcpcutdxfpy
8 gcpcutdxfpy gcp = gcodepreview(False, # generategcode
9 gcpcutdxfpy                                True # generatedxf
10 gcpcutdxfpy                                )
11 gcpcutdxfpy
12 gcpcutdxfpy # [Stock] */
13 gcpcutdxfpy stockXwidth = 100
14 gcpcutdxfpy # [Stock] */
15 gcpcutdxfpy stockYheight = 50
16 gcpcutdxfpy # [Stock] */
17 gcpcutdxfpy stockZthickness = 3.175
18 gcpcutdxfpy # [Stock] */
19 gcpcutdxfpy zeroheight = "Top" # [Top, Bottom]
20 gcpcutdxfpy # [Stock] */
21 gcpcutdxfpy stockzero = "Lower-Left" # [Lower-Left, Center-Left, Top-Left,
    Center]
22 gcpcutdxfpy # [Stock] */
23 gcpcutdxfpy retractheight = 3.175
24 gcpcutdxfpy
25 gcpcutdxfpy # [Export] */
26 gcpcutdxfpy Base_filename = "gcpdxf"
27 gcpcutdxfpy
```

```

28 gcpcutdxfp
29 gcpcutdxfp # [CAM] */
30 gcpcutdxfp large_square_tool_num = 112
31 gcpcutdxfp # [CAM] */
32 gcpcutdxfp small_square_tool_num = 0
33 gcpcutdxfp # [CAM] */
34 gcpcutdxfp large_ball_tool_num = 111
35 gcpcutdxfp # [CAM] */
36 gcpcutdxfp small_ball_tool_num = 0
37 gcpcutdxfp # [CAM] */
38 gcpcutdxfp large_V_tool_num = 0
39 gcpcutdxfp # [CAM] */
40 gcpcutdxfp small_V_tool_num = 0
41 gcpcutdxfp # [CAM] */
42 gcpcutdxfp DT_tool_num = 374
43 gcpcutdxfp # [CAM] */
44 gcpcutdxfp KH_tool_num = 0
45 gcpcutdxfp # [CAM] */
46 gcpcutdxfp Roundover_tool_num = 0
47 gcpcutdxfp # [CAM] */
48 gcpcutdxfp MISC_tool_num = 0
49 gcpcutdxfp
50 gcpcutdxfp # [Design] */
51 gcpcutdxfp inset = 3
52 gcpcutdxfp # [Design] */
53 gcpcutdxfp radius = 6
54 gcpcutdxfp # [Design] */
55 gcpcutdxfp cornerstyle = "Fillet" # "Chamfer", "Flipped Fillet"
56 gcpcutdxfp
57 gcpcutdxfp gcp.opendxfile(Base_filename)
58 gcpcutdxfp
59 gcpcutdxfp gcp.setupstock(stockXwidth, stockYheight, stockZthickness,
    zeroheight, stockzero, retractheight)
60 gcpcutdxfp
61 gcpcutdxfp gcp.toolchange(large_square_tool_num)
62 gcpcutdxfp
63 gcpcutdxfp gcp.setdxfcolor("Red")
64 gcpcutdxfp
65 gcpcutdxfp gcp.cutrectanglidxf(large_square_tool_num, 0, 0, 0, stockXwidth,
    stockYheight, stockZthickness)
66 gcpcutdxfp
67 gcpcutdxfp gcp.toolchange(large_ball_tool_num)
68 gcpcutdxfp
69 gcpcutdxfp gcp.setdxfcolor("Gray")
70 gcpcutdxfp
71 gcpcutdxfp gcp.rapid(inset + radius, inset, 0, "laser")
72 gcpcutdxfp
73 gcpcutdxfp gcp.cutlinedxf(inset + radius, inset, -stockZthickness/2)
74 gcpcutdxfp gcp.cutquarterCCNEdxf(inset, inset + radius, -stockZthickness/2,
    radius)
75 gcpcutdxfp
76 gcpcutdxfp gcp.cutlinedxf(inset, stockYheight - (inset + radius), -
    stockZthickness/2)
77 gcpcutdxfp
78 gcpcutdxfp gcp.cutquarterCCSEdxf(inset + radius, stockYheight - inset, -
    stockZthickness/2, radius)
79 gcpcutdxfp
80 gcpcutdxfp gcp.cutlinedxf(stockXwidth - (inset + radius), stockYheight - inset
    , -stockZthickness/2)
81 gcpcutdxfp
82 gcpcutdxfp gcp.cutquarterCCSWdxf(stockXwidth - inset, stockYheight - (inset +
    radius), -stockZthickness/2, radius)
83 gcpcutdxfp
84 gcpcutdxfp gcp.cutlinedxf(stockXwidth - (inset), (inset + radius), -
    stockZthickness/2)
85 gcpcutdxfp
86 gcpcutdxfp gcp.cutquarterCCNWdxf(stockXwidth - (inset + radius), inset, -
    stockZthickness/2, radius)
87 gcpcutdxfp
88 gcpcutdxfp gcp.cutlinedxf((inset + radius), inset, -stockZthickness/2)
89 gcpcutdxfp
90 gcpcutdxfp gcp.setdxfcolor("Blue")
91 gcpcutdxfp
92 gcpcutdxfp gcp.rapid(radius + inset + radius, radius, 0, "laser")
93 gcpcutdxfp
94 gcpcutdxfp gcp.cutrectanglerounddxf(large_square_tool_num, radius +inset,
    radius, 0, stockXwidth/2 - (radius * 4), stockYheight - (radius
    * 2), -stockZthickness/4, radius)

```

```

95 gcpcutdxfp
96 gcpcutdxfp gcp.rapid(stockXwidth/2 + (radius * 2) + inset + radius, radius, 0,
    "laser")

97 gcpcutdxfp
98 gcpcutdxfp gcp.cutrectanglerounddx(flarge_square_tool_num, stockXwidth/2 + (
    radius * 2) + inset, radius, 0, stockXwidth/2 - (radius * 4),
    stockYheight - (radius * 2), -stockZthickness/4, radius)

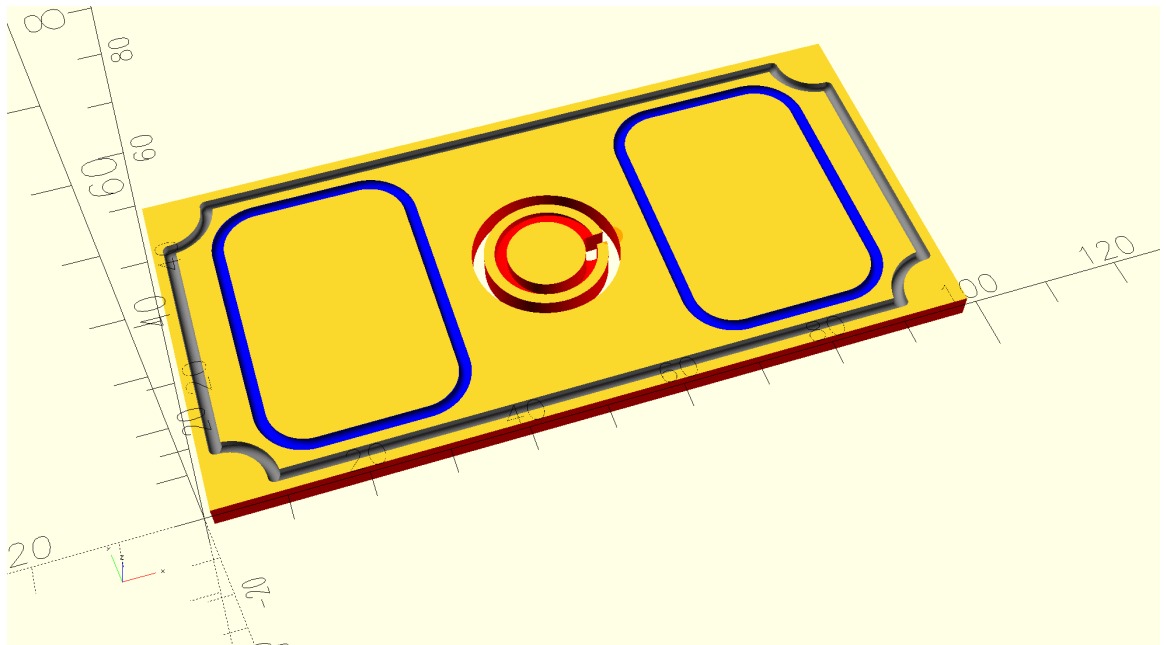
99 gcpcutdxfp
100 gcpcutdxfp gcp.setdxcolor("Red")
101 gcpcutdxfp
102 gcpcutdxfp gcp.rapid(stockXwidth/2 + radius, stockYheight/2, 0, "laser")
103 gcpcutdxfp
104 gcpcutdxfp gcp.toolchange(large_square_tool_num)
105 gcpcutdxfp
106 gcpcutdxfp gcp.cutcircleCC(stockXwidth/2, stockYheight/2, 0, -stockZthickness,
    radius)

107 gcpcutdxfp
108 gcpcutdxfp gcp.cutcircleCC(stockXwidth/2, stockYheight/2, -stockZthickness, -
    stockZthickness, radius*1.5)

109 gcpcutdxfp
110 gcpcutdxfp gcp.closedxf()
111 gcpcutdxfp
112 gcpcutdxfp gcp.stockandtoolpaths()

```

which creates the design:



and which allows an interactive usage in working up a design such as for lasercutting, and which incorporates an option to the `rapid(x,y,z)` command which simulates turning a laser off, repositioning, then powering up the laser after.

2.3 gcodepreviewtemplate.py

Note that since the v0.7 re-write, it is possible to directly use the underlying Python code. Using Python to generate 3D previews of how DXFs or G-code will cut requires the use of PythonSCAD.

```

1 gcptmplpy #!/usr/bin/env python
2 gcptmplpy
3 gcptmplpy import sys
4 gcptmplpy
5 gcptmplpy try:
6 gcptmplpy     if 'gcodepreview' in sys.modules:
7 gcptmplpy         del sys.modules['gcodepreview']
8 gcptmplpy except AttributeError:
9 gcptmplpy     pass
10 gcptmplpy
11 gcptmplpy from gcodepreview import *
12 gcptmplpy
13 gcptmplpy fa = 2
14 gcptmplpy fs = 0.125
15 gcptmplpy
16 gcptmplpy # [Export] */
17 gcptmplpy Base_filename = "aexport"
18 gcptmplpy # [Export] */
19 gcptmplpy generatedxf = True

```

```

20 gcptmplpy # [Export] */
21 gcptmplpy generategcode = True
22 gcptmplpy
23 gcptmplpy # [Stock] */
24 gcptmplpy stockXwidth = 220
25 gcptmplpy # [Stock] */
26 gcptmplpy stockYheight = 150
27 gcptmplpy # [Stock] */
28 gcptmplpy stockZthickness = 8.35
29 gcptmplpy # [Stock] */
30 gcptmplpy zeroheight = "Top" # [Top, Bottom]
31 gcptmplpy # [Stock] */
32 gcptmplpy stockzero = "Center" # [Lower-Left, Center-Left, Top-Left, Center]
33 gcptmplpy # [Stock] */
34 gcptmplpy retractheight = 9
35 gcptmplpy
36 gcptmplpy # [CAM] */
37 gcptmplpy toolradius = 1.5875
38 gcptmplpy # [CAM] */
39 gcptmplpy large_square_tool_num = 201 # [0:0, 112:112, 102:102, 201:201]
40 gcptmplpy # [CAM] */
41 gcptmplpy small_square_tool_num = 102 # [0:0, 122:122, 112:112, 102:102]
42 gcptmplpy # [CAM] */
43 gcptmplpy large_ball_tool_num = 202 # [0:0, 111:111, 101:101, 202:202]
44 gcptmplpy # [CAM] */
45 gcptmplpy small_ball_tool_num = 101 # [0:0, 121:121, 111:111, 101:101]
46 gcptmplpy # [CAM] */
47 gcptmplpy large_V_tool_num = 301 # [0:0, 301:301, 690:690]
48 gcptmplpy # [CAM] */
49 gcptmplpy small_V_tool_num = 390 # [0:0, 390:390, 301:301]
50 gcptmplpy # [CAM] */
51 gcptmplpy DT_tool_num = 814 # [0:0, 814:814, 808079:808079]
52 gcptmplpy # [CAM] */
53 gcptmplpy KH_tool_num = 374 # [0:0, 374:374, 375:375, 376:376, 378:378]
54 gcptmplpy # [CAM] */
55 gcptmplpy Roundover_tool_num = 56142 # [56142:56142, 56125:56125, 1570:1570]
56 gcptmplpy # [CAM] */
57 gcptmplpy MISC_tool_num = 0 # [501:501, 502:502, 45982:45982]
58 gcptmplpy #501 https://shop.carbide3d.com/collections/cutters/products/501-
    engraving-bit
59 gcptmplpy #502 https://shop.carbide3d.com/collections/cutters/products/502-
    engraving-bit
60 gcptmplpy #204 tapered ball nose 0.0625", 0.2500", 1.50", 3.6ř
61 gcptmplpy #304 tapered ball nose 0.1250", 0.2500", 1.50", 2.4ř
62 gcptmplpy #648 threadmill_shaft(2.4, 0.75, 18)
63 gcptmplpy #45982 Carbide Tipped Bowl & Tray 1/4 Radius x 3/4 Dia x 5/8 x 1/4
    Inch Shank
64 gcptmplpy #13921 https://www.amazon.com/Yonico-Groove-Bottom-Router-Degree/dp
    /BOCPJPTMP
65 gcptmplpy
66 gcptmplpy # [Feeds and Speeds] */
67 gcptmplpy plunge = 100
68 gcptmplpy # [Feeds and Speeds] */
69 gcptmplpy feed = 400
70 gcptmplpy # [Feeds and Speeds] */
71 gcptmplpy speed = 16000
72 gcptmplpy # [Feeds and Speeds] */
73 gcptmplpy small_square_ratio = 0.75 # [0.25:2]
74 gcptmplpy # [Feeds and Speeds] */
75 gcptmplpy large_ball_ratio = 1.0 # [0.25:2]
76 gcptmplpy # [Feeds and Speeds] */
77 gcptmplpy small_ball_ratio = 0.75 # [0.25:2]
78 gcptmplpy # [Feeds and Speeds] */
79 gcptmplpy large_V_ratio = 0.875 # [0.25:2]
80 gcptmplpy # [Feeds and Speeds] */
81 gcptmplpy small_V_ratio = 0.625 # [0.25:2]
82 gcptmplpy # [Feeds and Speeds] */
83 gcptmplpy DT_ratio = 0.75 # [0.25:2]
84 gcptmplpy # [Feeds and Speeds] */
85 gcptmplpy KH_ratio = 0.75 # [0.25:2]
86 gcptmplpy # [Feeds and Speeds] */
87 gcptmplpy RO_ratio = 0.5 # [0.25:2]
88 gcptmplpy # [Feeds and Speeds] */
89 gcptmplpy MISC_ratio = 0.5 # [0.25:2]
90 gcptmplpy
91 gcptmplpy gcp = gcodepreview(generategcode,
92 gcptmplpy generatedxf,
93 gcptmplpy )

```

```

94 gcptmplpy
95 gcptmplpy gcp.opengcodefile(Base_filename)
96 gcptmplpy gcp.opendxfile(Base_filename)
97 gcptmplpy gcp.opendxfiles(Base_filename,
98 gcptmplpy         large_square_tool_num,
99 gcptmplpy         small_square_tool_num,
100 gcptmplpy         large_ball_tool_num,
101 gcptmplpy         small_ball_tool_num,
102 gcptmplpy         large_V_tool_num,
103 gcptmplpy         small_V_tool_num,
104 gcptmplpy         DT_tool_num,
105 gcptmplpy         KH_tool_num,
106 gcptmplpy         Roundover_tool_num,
107 gcptmplpy         MISC_tool_num)
108 gcptmplpy gcp.setupstock(stockXwidth, stockYheight, stockZthickness,
        zeroheight, stockzero, retractheight)

109 gcptmplpy
110 gcptmplpy gcp.movetosafeZ()
111 gcptmplpy
112 gcptmplpy gcp.toolchange(102, 10000)
113 gcptmplpy
114 gcptmplpy gcp.rapidZ(0)
115 gcptmplpy
116 gcptmplpy gcp.cutlinedxfgc(stockXwidth/2, stockYheight/2, -stockZthickness)
117 gcptmplpy
118 gcptmplpy gcp.rapidZ(retractheight)
119 gcptmplpy gcp.toolchange(201, 10000)
120 gcptmplpy gcp.rapidXY(0, stockYheight/16)
121 gcptmplpy gcp.rapidZ(0)
122 gcptmplpy gcp.cutlinedxfgc(stockXwidth/16*7, stockYheight/2, -stockZthickness
        )

123 gcptmplpy
124 gcptmplpy gcp.rapidZ(retractheight)
125 gcptmplpy gcp.toolchange(202, 10000)
126 gcptmplpy gcp.rapidXY(0, stockYheight/8)
127 gcptmplpy gcp.rapidZ(0)
128 gcptmplpy gcp.cutlinedxfgc(stockXwidth/16*6, stockYheight/2, -stockZthickness
        )

129 gcptmplpy
130 gcptmplpy gcp.rapidZ(retractheight)
131 gcptmplpy gcp.toolchange(101, 10000)
132 gcptmplpy gcp.rapidXY(0, stockYheight/16*3)
133 gcptmplpy gcp.rapidZ(0)
134 gcptmplpy gcp.cutlinedxfgc(stockXwidth/16*5, stockYheight/2, -stockZthickness
        )

135 gcptmplpy
136 gcptmplpy gcp.setzpos(retractheight)
137 gcptmplpy gcp.toolchange(390, 10000)
138 gcptmplpy gcp.rapidXY(0, stockYheight/16*4)
139 gcptmplpy gcp.rapidZ(0)
140 gcptmplpy gcp.cutlinedxfgc(stockXwidth/16*4, stockYheight/2, -stockZthickness
        )

141 gcptmplpy gcp.rapidZ(retractheight)
142 gcptmplpy
143 gcptmplpy gcp.toolchange(301, 10000)
144 gcptmplpy gcp.rapidXY(0, stockYheight/16*6)
145 gcptmplpy gcp.rapidZ(0)
146 gcptmplpy gcp.cutlinedxfgc(stockXwidth/16*2, stockYheight/2, -stockZthickness
        )

147 gcptmplpy
148 gcptmplpy rapids = gcp.rapid(gcp.xpos(), gcp.ypos(), retractheight)
149 gcptmplpy gcp.toolchange(102, 10000)
150 gcptmplpy
151 gcptmplpy gcp.rapid(-stockXwidth/4+stockYheight/16, +stockYheight/4, 0)
152 gcptmplpy
153 gcptmplpy #gcp.cutarcCC(0, 90, gcp.xpos()-stockYheight/16, gcp.ypos(),
        stockYheight/16, -stockZthickness/4)
154 gcptmplpy #gcp.cutarcCC(90, 180, gcp.xpos(), gcp.ypos()-stockYheight/16,
        stockYheight/16, -stockZthickness/4)
155 gcptmplpy #gcp.cutarcCC(180, 270, gcp.xpos()+stockYheight/16, gcp.ypos(),
        stockYheight/16, -stockZthickness/4)
156 gcptmplpy #gcp.cutarcCC(270, 360, gcp.xpos(), gcp.ypos()+stockYheight/16,
        stockYheight/16, -stockZthickness/4)
157 gcptmplpy gcp.cutquarterCCNEdxf(gcp.xpos() - stockYheight/8, gcp.ypos() +
        stockYheight/8, -stockZthickness/4, stockYheight/8)
158 gcptmplpy gcp.cutquarterCCNWdxf(gcp.xpos() - stockYheight/8, gcp.ypos() -
        stockYheight/8, -stockZthickness/2, stockYheight/8)
159 gcptmplpy gcp.cutquarterCCSWdxf(gcp.xpos() + stockYheight/8, gcp.ypos() -

```

```

        stockYheight/8, -stockZthickness * 0.75, stockYheight/8)
160 gcptmplpy gcp.cutquarterCCSEdxf(gcp.xpos() + stockYheight/8, gcp.ypos() +
        stockYheight/8, -stockZthickness, stockYheight/8)
161 gcptmplpy
162 gcptmplpy gcp.movetosafeZ()
163 gcptmplpy gcp.rapidXY(stockXwidth/4-stockYheight/16, -stockYheight/4)
164 gcptmplpy gcp.rapidZ(0)
165 gcptmplpy
166 gcptmplpy
167 gcptmplpy #gcp.cutarcCW(180, 90, gcp.xpos()+stockYheight/16, gcp.ypos(),
        stockYheight/16, -stockZthickness/4)
168 gcptmplpy #gcp.cutarcCW(90, 0, gcp.xpos(), gcp.ypos()-stockYheight/16,
        stockYheight/16, -stockZthickness/4)
169 gcptmplpy #gcp.cutarcCW(360, 270, gcp.xpos()-stockYheight/16, gcp.ypos(),
        stockYheight/16, -stockZthickness/4)
170 gcptmplpy #gcp.cutarcCW(270, 180, gcp.xpos(), gcp.ypos()+stockYheight/16,
        stockYheight/16, -stockZthickness/4)
171 gcptmplpy
172 gcptmplpy #gcp.movetosafeZ()
173 gcptmplpy #gcp.toolchange(201, 10000)
174 gcptmplpy #gcp.rapidXY(stockXwidth/2, -stockYheight/2)
175 gcptmplpy #gcp.rapidZ(0)
176 gcptmplpy
177 gcptmplpy #gcp.cutlinedxfgc(gcp.xpos(), gcp.ypos(), -stockZthickness)
178 gcptmplpy #test = gcp.cutlinedxfgc(gcp.xpos(), gcp.ypos(), -stockZthickness)
179 gcptmplpy
180 gcptmplpy #gcp.movetosafeZ()
181 gcptmplpy #gcp.rapidXY(stockXwidth/2-6.34, -stockYheight/2)
182 gcptmplpy #gcp.rapidZ(0)
183 gcptmplpy
184 gcptmplpy #gcp.cutarcCW(180, 90, stockXwidth/2, -stockYheight/2, 6.34, -
        stockZthickness)
185 gcptmplpy
186 gcptmplpy
187 gcptmplpy gcp.movetosafeZ()
188 gcptmplpy gcp.toolchange(814, 10000)
189 gcptmplpy gcp.rapidXY(0, -(stockYheight/2+12.7))
190 gcptmplpy gcp.rapidZ(0)
191 gcptmplpy
192 gcptmplpy gcp.cutlinedxfgc(gcp.xpos(), gcp.ypos(), -stockZthickness)
193 gcptmplpy gcp.cutlinedxfgc(gcp.xpos(), -12.7, -stockZthickness)
194 gcptmplpy
195 gcptmplpy gcp.rapidXY(0, -(stockYheight/2+12.7))
196 gcptmplpy gcp.movetosafeZ()
197 gcptmplpy gcp.toolchange(374, 10000)
198 gcptmplpy gcp.rapidXY(stockXwidth/4-stockXwidth/16, -(stockYheight/4+
        stockYheight/16))
199 gcptmplpy gcp.rapidZ(0)
200 gcptmplpy
201 gcptmplpy gcp.rapidZ(retractheight)
202 gcptmplpy gcp.toolchange(374, 10000)
203 gcptmplpy gcp.rapidXY(-stockXwidth/4-stockXwidth/16, -(stockYheight/4+
        stockYheight/16))
204 gcptmplpy gcp.rapidZ(0)
205 gcptmplpy
206 gcptmplpy gcp.cutline(gcp.xpos(), gcp.ypos(), -stockZthickness/2)
207 gcptmplpy gcp.cutlinedxfgc(gcp.xpos()+stockYheight/9, gcp.ypos(), gcp.zpos())
208 gcptmplpy
209 gcptmplpy gcp.cutline(gcp.xpos()-stockYheight/9, gcp.ypos(), gcp.zpos())
210 gcptmplpy gcp.cutline(gcp.xpos(), gcp.ypos(), 0)
211 gcptmplpy
212 gcptmplpy #key = gcp.cutkeyholegcdxf(KH_tool_num, 0, stockZthickness*0.75, "E
        ", stockYheight/9)
213 gcptmplpy #key = gcp.cutKHgcdxf(374, 0, stockZthickness*0.75, 90,
        stockYheight/9)
214 gcptmplpy #toolpaths = toolpaths.union(key)
215 gcptmplpy
216 gcptmplpy gcp.rapidZ(retractheight)
217 gcptmplpy gcp.rapidXY(-stockXwidth/4+stockXwidth/16, -(stockYheight/4+
        stockYheight/16))
218 gcptmplpy gcp.rapidZ(0)
219 gcptmplpy gcp.cutline(gcp.xpos(), gcp.ypos(), -stockZthickness/2)
220 gcptmplpy gcp.cutlinedxfgc(gcp.xpos(), gcp.ypos()+stockYheight/9, gcp.zpos())
221 gcptmplpy
222 gcptmplpy gcp.cutline(gcp.xpos(), gcp.ypos()-stockYheight/9, gcp.zpos())
223 gcptmplpy gcp.cutline(gcp.xpos(), gcp.ypos(), 0)
224 gcptmplpy
225 gcptmplpy gcp.rapidZ(retractheight)

```

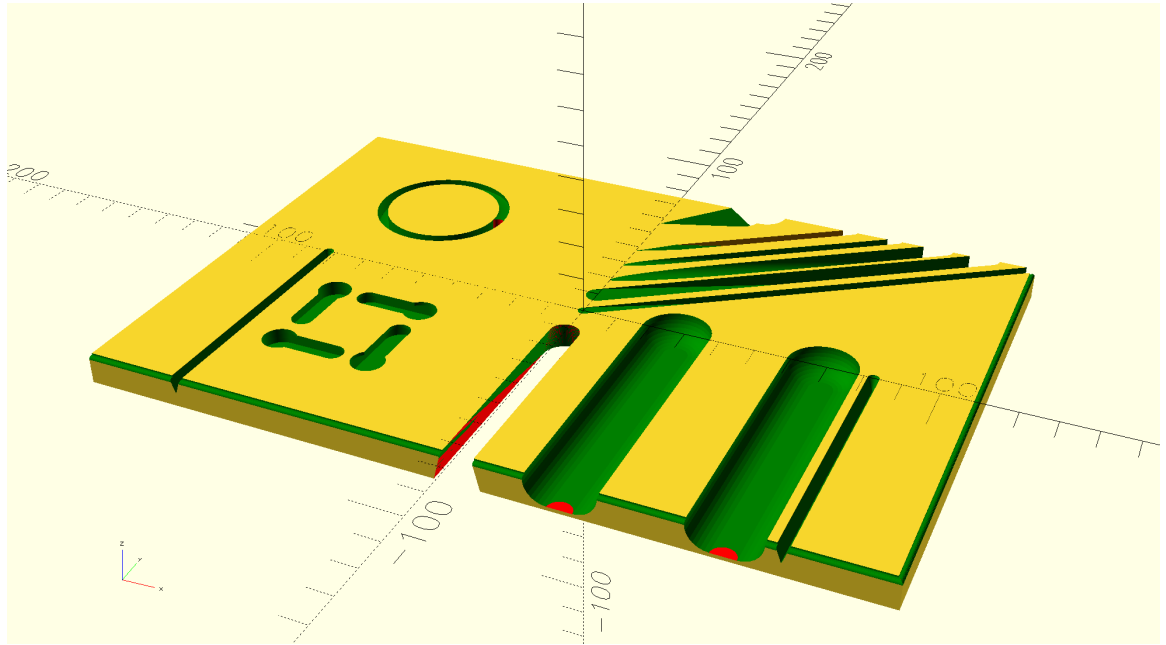


```

226 gcptmplpy gcp.rapidXY(-stockXwidth/4+stockXwidth/16, -(stockYheight/4-
    stockYheight/8))
227 gcptmplpy gcp.rapidZ(0)
228 gcptmplpy
229 gcptmplpy gcp.cutline(gcp.xpos(), gcp.ypos(), -stockZthickness/2)
230 gcptmplpy gcp.cutlinedxfgc(gcp.xpos()-stockYheight/9, gcp.ypos(), gcp.zpos())
231 gcptmplpy
232 gcptmplpy gcp.cutline(gcp.xpos()+stockYheight/9, gcp.ypos(), gcp.zpos())
233 gcptmplpy gcp.cutline(gcp.xpos(), gcp.ypos(), 0)
234 gcptmplpy
235 gcptmplpy gcp.rapidZ(retractheight)
236 gcptmplpy gcp.rapidXY(-stockXwidth/4-stockXwidth/16, -(stockYheight/4-
    stockYheight/8))
237 gcptmplpy gcp.rapidZ(0)
238 gcptmplpy gcp.cutline(gcp.xpos(), gcp.ypos(), -stockZthickness/2)
239 gcptmplpy gcp.cutlinedxfgc(gcp.xpos(), gcp.ypos()-stockYheight/9, gcp.zpos())
240 gcptmplpy gcp.cutline(gcp.xpos(), gcp.ypos()+stockYheight/9, gcp.zpos())
241 gcptmplpy gcp.cutline(gcp.xpos(), gcp.ypos(), 0)
242 gcptmplpy
243 gcptmplpy gcp.rapidZ(retractheight)
244 gcptmplpy gcp.toolchange(56142, 10000)
245 gcptmplpy gcp.rapidXY(-stockXwidth/2, -(stockYheight/2+0.508/2))
246 gcptmplpy gcp.cutline(gcp.xpos(), gcp.ypos(), -1.531)
247 gcptmplpy gcp.cutlinedxfgc(stockXwidth/2+0.508/2, -(stockYheight/2+0.508/2),
    -1.531)
248 gcptmplpy
249 gcptmplpy gcp.rapidZ(retractheight)
250 gcptmplpy
251 gcptmplpy gcp.cutline(gcp.xpos(), gcp.ypos(), -1.531)
252 gcptmplpy gcp.cutlinedxfgc(stockXwidth/2+0.508/2, (stockYheight/2+0.508/2),
    -1.531)
253 gcptmplpy
254 gcptmplpy gcp.rapidZ(retractheight)
255 gcptmplpy gcp.toolchange(45982, 10000)
256 gcptmplpy gcp.rapidXY(stockXwidth/8, 0)
257 gcptmplpy gcp.cutline(gcp.xpos(), gcp.ypos(), -(stockZthickness*7/8))
258 gcptmplpy gcp.cutlinedxfgc(gcp.xpos(), -stockYheight/2, -(stockZthickness
    *7/8))
259 gcptmplpy
260 gcptmplpy gcp.rapidZ(retractheight)
261 gcptmplpy gcp.toolchange(204, 10000)
262 gcptmplpy gcp.rapidXY(stockXwidth*0.3125, 0)
263 gcptmplpy gcp.cutline(gcp.xpos(), gcp.ypos(), -(stockZthickness*7/8))
264 gcptmplpy gcp.cutlinedxfgc(gcp.xpos(), -stockYheight/2, -(stockZthickness
    *7/8))
265 gcptmplpy
266 gcptmplpy gcp.rapidZ(retractheight)
267 gcptmplpy gcp.toolchange(502, 10000)
268 gcptmplpy gcp.rapidXY(stockXwidth*0.375, 0)
269 gcptmplpy gcp.cutline(gcp.xpos(), gcp.ypos(), -4.24)
270 gcptmplpy gcp.cutlinedxfgc(gcp.xpos(), -stockYheight/2, -4.24)
271 gcptmplpy
272 gcptmplpy gcp.rapidZ(retractheight)
273 gcptmplpy gcp.toolchange(13921, 10000)
274 gcptmplpy gcp.rapidXY(-stockXwidth*0.375, 0)
275 gcptmplpy gcp.cutline(gcp.xpos(), gcp.ypos(), -stockZthickness/2)
276 gcptmplpy gcp.cutlinedxfgc(gcp.xpos(), -stockYheight/2, -stockZthickness/2)
277 gcptmplpy
278 gcptmplpy gcp.rapidZ(retractheight)
279 gcptmplpy
280 gcptmplpy gcp.stockandtoolpaths()
281 gcptmplpy
282 gcptmplpy gcp.closegcodefile()
283 gcptmplpy gcp.closedxfiles()
284 gcptmplpy gcp.closedxfile()

```

Which generates a 3D model which previews in PythonSCAD as:



2.4 gcodepreviewtemplate.scad

Since the project began in OpenSCAD, having an implementation in that language has always been a goal. This is quite straight-forward since the Python code when imported into OpenSCAD may be accessed by quite simple modules which are for the most part, a series of decorators/de-descriptors which wrap up the Python definitions as OpenSCAD modules. Moreover, such an implementation will facilitate usage by tools intended for this application such as OpenSCAD Graph Editor: <https://github.com/derkork/openscad-graph-editor>.

```

1 gcptmpl //!OpenSCAD
2 gcptmpl
3 gcptmpl use <gcodepreview.py>
4 gcptmpl include <gcodepreview.scad>
5 gcptmpl
6 gcptmpl $fa = 2;
7 gcptmpl $fs = 0.125;
8 gcptmpl fa = 2;
9 gcptmpl fs = 0.125;
10 gcptmpl
11 gcptmpl /* [Stock] */
12 gcptmpl stockXwidth = 220;
13 gcptmpl /* [Stock] */
14 gcptmpl stockYheight = 150;
15 gcptmpl /* [Stock] */
16 gcptmpl stockZthickness = 8.35;
17 gcptmpl /* [Stock] */
18 gcptmpl zeroheight = "Top"; // [Top, Bottom]
19 gcptmpl /* [Stock] */
20 gcptmpl stockzero = "Center"; // [Lower-Left, Center-Left, Top-Left, Center
    ]
21 gcptmpl /* [Stock] */
22 gcptmpl retractheight = 9;
23 gcptmpl
24 gcptmpl /* [Export] */
25 gcptmpl Base_filename = "export";
26 gcptmpl /* [Export] */
27 gcptmpl generatedxf = true;
28 gcptmpl /* [Export] */
29 gcptmpl generategcode = true;
30 gcptmpl
31 gcptmpl /* [CAM] */
32 gcptmpl toolradius = 1.5875;
33 gcptmpl /* [CAM] */
34 gcptmpl large_square_tool_num = 0; // [0:0, 112:112, 102:102, 201:201]
35 gcptmpl /* [CAM] */
36 gcptmpl small_square_tool_num = 102; // [0:0, 122:122, 112:112, 102:102]
37 gcptmpl /* [CAM] */
38 gcptmpl large_ball_tool_num = 0; // [0:0, 111:111, 101:101, 202:202]
39 gcptmpl /* [CAM] */
40 gcptmpl small_ball_tool_num = 0; // [0:0, 121:121, 111:111, 101:101]
41 gcptmpl /* [CAM] */
42 gcptmpl large_V_tool_num = 0; // [0:0, 301:301, 690:690]
43 gcptmpl /* [CAM] */

```

```

44 gcptmpl small_V_tool_num = 0; // [0:0, 390:390, 301:301]
45 gcptmpl /* [CAM] */
46 gcptmpl DT_tool_num = 0; // [0:0, 814:814, 808079:808079]
47 gcptmpl /* [CAM] */
48 gcptmpl KH_tool_num = 0; // [0:0, 374:374, 375:375, 376:376, 378:378]
49 gcptmpl /* [CAM] */
50 gcptmpl Roundover_tool_num = 0; // [56142:56142, 56125:56125, 1570:1570]
51 gcptmpl /* [CAM] */
52 gcptmpl MISC_tool_num = 0; // [648:648, 45982:45982]
53 gcptmpl //648 threadmill_shaft(2.4, 0.75, 18)
54 gcptmpl //45982 Carbide Tipped Bowl & Tray 1/4 Radius x 3/4 Dia x 5/8 x 1/4
      Inch Shank
55 gcptmpl
56 gcptmpl /* [Feeds and Speeds] */
57 gcptmpl plunge = 100;
58 gcptmpl /* [Feeds and Speeds] */
59 gcptmpl feed = 400;
60 gcptmpl /* [Feeds and Speeds] */
61 gcptmpl speed = 16000;
62 gcptmpl /* [Feeds and Speeds] */
63 gcptmpl small_square_ratio = 0.75; // [0.25:2]
64 gcptmpl /* [Feeds and Speeds] */
65 gcptmpl large_ball_ratio = 1.0; // [0.25:2]
66 gcptmpl /* [Feeds and Speeds] */
67 gcptmpl small_ball_ratio = 0.75; // [0.25:2]
68 gcptmpl /* [Feeds and Speeds] */
69 gcptmpl large_V_ratio = 0.875; // [0.25:2]
70 gcptmpl /* [Feeds and Speeds] */
71 gcptmpl small_V_ratio = 0.625; // [0.25:2]
72 gcptmpl /* [Feeds and Speeds] */
73 gcptmpl DT_ratio = 0.75; // [0.25:2]
74 gcptmpl /* [Feeds and Speeds] */
75 gcptmpl KH_ratio = 0.75; // [0.25:2]
76 gcptmpl /* [Feeds and Speeds] */
77 gcptmpl RO_ratio = 0.5; // [0.25:2]
78 gcptmpl /* [Feeds and Speeds] */
79 gcptmpl MISC_ratio = 0.5; // [0.25:2]
80 gcptmpl
81 gcptmpl thegeneratedxf = generatedxf == true ? 1 : 0;
82 gcptmpl thegenerategcode = generategcode == true ? 1 : 0;
83 gcptmpl
84 gcptmpl gcp = gcodepreview(thegenerategcode,
85 gcptmpl                      thegeneratedxf,
86 gcptmpl                      );
87 gcptmpl
88 gcptmpl.opengcodefile(Base_filename);
89 gcptmpl.opendxxfile(Base_filename);
90 gcptmpl.opendxxfiles(Base_filename,
91 gcptmpl                      large_square_tool_num,
92 gcptmpl                      small_square_tool_num,
93 gcptmpl                      large_ball_tool_num,
94 gcptmpl                      small_ball_tool_num,
95 gcptmpl                      large_V_tool_num,
96 gcptmpl                      small_V_tool_num,
97 gcptmpl                      DT_tool_num,
98 gcptmpl                      KH_tool_num,
99 gcptmpl                      Roundover_tool_num,
100 gcptmpl                      MISC_tool_num);
101 gcptmpl
102 gcptmpl.setupstock(stockXwidth, stockYheight, stockZthickness, zeroheight,
      stockzero);
103 gcptmpl
104 gcptmpl //echo(gcp);
105 gcptmpl //gcpversion();
106 gcptmpl
107 gcptmpl //c = myfunc(4);
108 gcptmpl //echo(c);
109 gcptmpl
110 gcptmpl //echo(getvv());
111 gcptmpl
112 gcptmpl.outline(stockXwidth/2, stockYheight/2, -stockZthickness);
113 gcptmpl
114 gcptmpl.rapidZ(retractheight);
115 gcptmpl.toolchange(201, 10000);
116 gcptmpl.rapidXY(0, stockYheight/16);
117 gcptmpl.rapidZ(0);
118 gcptmpl.cutlinedxfgc(stockXwidth/16*7, stockYheight/2, -stockZthickness);
119 gcptmpl

```

```

120 gcptmpl
121 gcptmpl rapidZ(retractheight);
122 gcptmpl toolchange(202, 10000);
123 gcptmpl rapidXY(0, stockYheight/8);
124 gcptmpl rapidZ(0);
125 gcptmpl cutlinedxfgc(stockXwidth/16*6, stockYheight/2, -stockZthickness);
126 gcptmpl
127 gcptmpl rapidZ(retractheight);
128 gcptmpl toolchange(101, 10000);
129 gcptmpl rapidXY(0, stockYheight/16*3);
130 gcptmpl rapidZ(0);
131 gcptmpl cutlinedxfgc(stockXwidth/16*5, stockYheight/2, -stockZthickness);
132 gcptmpl
133 gcptmpl rapidZ(retractheight);
134 gcptmpl toolchange(390, 10000);
135 gcptmpl rapidXY(0, stockYheight/16*4);
136 gcptmpl rapidZ(0);
137 gcptmpl
138 gcptmpl cutlinedxfgc(stockXwidth/16*4, stockYheight/2, -stockZthickness);
139 gcptmpl rapidZ(retractheight);
140 gcptmpl
141 gcptmpl toolchange(301, 10000);
142 gcptmpl rapidXY(0, stockYheight/16*6);
143 gcptmpl rapidZ(0);
144 gcptmpl
145 gcptmpl cutlinedxfgc(stockXwidth/16*2, stockYheight/2, -stockZthickness);
146 gcptmpl
147 gcptmpl
148 gcptmpl movetosafeZ();
149 gcptmpl rapid(gcp.xpos(), gcp.ypos(), retractheight);
150 gcptmpl toolchange(102, 10000);
151 gcptmpl
152 gcptmpl //rapidXY(stockXwidth/4+stockYheight/8+stockYheight/16, +
      stockYheight/8);
153 gcptmpl rapidXY(-stockXwidth/4+stockXwidth/16, (stockYheight/4));//+
      stockYheight/16
154 gcptmpl rapidZ(0);
155 gcptmpl
156 gcptmpl //cutarcCW(360, 270, gcp.xpos()-stockYheight/16, gcp.ypos(),
      stockYheight/16, -stockZthickness);
157 gcptmpl //gcp.cutarcCW(270, 180, gcp.xpos(), gcp.ypos()+stockYheight/16,
      stockYheight/16))
158 gcptmpl //cutarcCC(0, 90, gcp.xpos()-stockYheight/16, gcp.ypos(),
      stockYheight/16, -stockZthickness/4);
159 gcptmpl //cutarcCC(90, 180, gcp.xpos(), gcp.ypos()-stockYheight/16,
      stockYheight/16, -stockZthickness/4);
160 gcptmpl //cutarcCC(180, 270, gcp.xpos()+stockYheight/16, gcp.ypos(),
      stockYheight/16, -stockZthickness/4);
161 gcptmpl //cutarcCC(270, 360, gcp.xpos(), gcp.ypos()+stockYheight/16,
      stockYheight/16, -stockZthickness/4);
162 gcptmpl
163 gcptmpl movetosafeZ();
164 gcptmpl //rapidXY(stockXwidth/4+stockYheight/8-stockYheight/16, -
      stockYheight/8);
165 gcptmpl rapidXY(stockXwidth/4-stockYheight/16, -(stockYheight/4));
166 gcptmpl rapidZ(0);
167 gcptmpl
168 gcptmpl //cutarcCW(180, 90, gcp.xpos()+stockYheight/16, gcp.ypos(),
      stockYheight/16, -stockZthickness/4);
169 gcptmpl //cutarcCW(90, 0, gcp.xpos(), gcp.ypos()-stockYheight/16,
      stockYheight/16, -stockZthickness/4);
170 gcptmpl //cutarcCW(360, 270, gcp.xpos()-stockYheight/16, gcp.ypos(),
      stockYheight/16, -stockZthickness/4);
171 gcptmpl //cutarcCW(270, 180, gcp.xpos(), gcp.ypos()+stockYheight/16,
      stockYheight/16, -stockZthickness/4);
172 gcptmpl
173 gcptmpl movetosafeZ();
174 gcptmpl
175 gcptmpl rapidXY(-stockXwidth/4 + stockYheight/8, (stockYheight/4));
176 gcptmpl rapidZ(0);
177 gcptmpl
178 gcptmpl cutquarterCCNEdxf(xpos() - stockYheight/8, ypos() + stockYheight/8,
      -stockZthickness/4, stockYheight/8);
179 gcptmpl cutquarterCCNWdxf(xpos() - stockYheight/8, ypos() - stockYheight/8,
      -stockZthickness/2, stockYheight/8);
180 gcptmpl cutquarterCCSWdxf(xpos() + stockYheight/8, ypos() - stockYheight/8,
      -stockZthickness * 0.75, stockYheight/8);
181 gcptmpl //cutquarterCCSEdxf(xpos() + stockYheight/8, ypos() + stockYheight

```

```

        /8, -stockZthickness, stockYheight/8);
182 gcptmpl
183 gcptmpl movetosafeZ();
184 gcptmpl toolchange(201, 10000);
185 gcptmpl rapidXY(stockXwidth /2 -6.34, - stockYheight /2);
186 gcptmpl rapidZ(0);
187 gcptmpl //cutarcCW(180, 90, stockXwidth /2, -stockYheight/2, 6.34, -
        stockZthickness);
188 gcptmpl
189 gcptmpl movetosafeZ();
190 gcptmpl rapidXY(stockXwidth/2, -stockYheight/2);
191 gcptmpl rapidZ(0);
192 gcptmpl
193 gcptmpl //gcp.cutlinedxfgc(gcp.xpos(), gcp.ypos(), -stockZthickness);
194 gcptmpl
195 gcptmpl movetosafeZ();
196 gcptmpl toolchange(814, 10000);
197 gcptmpl rapidXY(0, -(stockYheight/2+12.7));
198 gcptmpl rapidZ(0);
199 gcptmpl
200 gcptmpl cutlinedxfgc(xpos(), ypos(), -stockZthickness);
201 gcptmpl cutlinedxfgc(xpos(), -12.7, -stockZthickness);
202 gcptmpl rapidXY(0, -(stockYheight/2+12.7));
203 gcptmpl
204 gcptmpl //rapidXY(stockXwidth/2-6.34, -stockYheight/2);
205 gcptmpl //rapidZ(0);
206 gcptmpl
207 gcptmpl //movetosafeZ();
208 gcptmpl //toolchange(374, 10000);
209 gcptmpl //rapidXY(-(stockXwidth/4 - stockXwidth /16), -(stockYheight/4 +
        stockYheight/16))
210 gcptmpl
211 gcptmpl //cutline(xpos(), ypos(), (stockZthickness/2) * -1);
212 gcptmpl //cutlinedxfgc(xpos() + stockYheight /9, ypos(), zpos());
213 gcptmpl //cutline(xpos() - stockYheight /9, ypos(), zpos());
214 gcptmpl //cutline(xpos(), ypos(), 0);
215 gcptmpl
216 gcptmpl movetosafeZ();
217 gcptmpl
218 gcptmpl toolchange(374, 10000);
219 gcptmpl rapidXY(-stockXwidth/4-stockXwidth/16, -(stockYheight/4+
        stockYheight/16))
220 gcptmpl //rapidXY(-(stockXwidth/4 - stockXwidth /16), -(stockYheight/4 +
        stockYheight/16))
221 gcptmpl rapidZ(0);
222 gcptmpl
223 gcptmpl cutline(xpos(), ypos(), (stockZthickness/2) * -1);
224 gcptmpl cutlinedxfgc(xpos() + stockYheight /9, ypos(), zpos());
225 gcptmpl cutline(xpos() - stockYheight /9, ypos(), zpos());
226 gcptmpl cutline(xpos(), ypos(), 0);
227 gcptmpl
228 gcptmpl rapidZ(retractheight);
229 gcptmpl rapidXY(-stockXwidth/4+stockXwidth/16, -(stockYheight/4+
        stockYheight/16));
230 gcptmpl rapidZ(0);
231 gcptmpl cutline(gcp.xpos(), gcp.ypos(), -stockZthickness/2);
232 gcptmpl cutlinedxfgc(gcp.xpos(), gcp.ypos()+stockYheight/9, gcp.zpos());
233 gcptmpl cutline(gcp.xpos(), gcp.ypos()-stockYheight/9, gcp.zpos());
234 gcptmpl cutline(gcp.xpos(), gcp.ypos(), 0);
235 gcptmpl
236 gcptmpl rapidZ(retractheight);
237 gcptmpl rapidXY(-stockXwidth/4+stockXwidth/16, -(stockYheight/4-
        stockYheight/8));
238 gcptmpl rapidZ(0);
239 gcptmpl cutline(gcp.xpos(), gcp.ypos(), -stockZthickness/2);
240 gcptmpl cutlinedxfgc(gcp.xpos()-stockYheight/9, gcp.ypos(), gcp.zpos());
241 gcptmpl cutline(gcp.xpos()+stockYheight/9, gcp.ypos(), gcp.zpos());
242 gcptmpl cutline(gcp.xpos(), gcp.ypos(), 0);
243 gcptmpl
244 gcptmpl rapidZ(retractheight);
245 gcptmpl rapidXY(-stockXwidth/4-stockXwidth/16, -(stockYheight/4-
        stockYheight/8));
246 gcptmpl rapidZ(0);
247 gcptmpl cutline(gcp.xpos(), gcp.ypos(), -stockZthickness/2);
248 gcptmpl cutlinedxfgc(gcp.xpos(), gcp.ypos()-stockYheight/9, gcp.zpos());
249 gcptmpl cutline(gcp.xpos(), gcp.ypos()+stockYheight/9, gcp.zpos());
250 gcptmpl cutline(gcp.xpos(), gcp.ypos(), 0);
251 gcptmpl

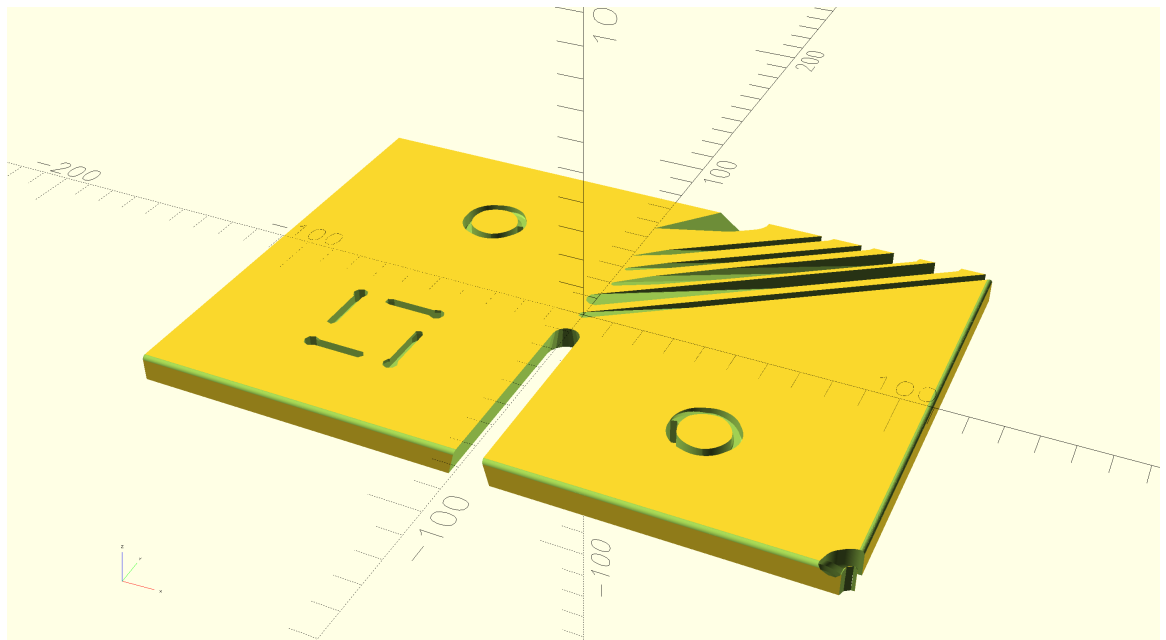
```

```

252 gcptmpl rapidZ(retractheight);
253 gcptmpl toolchange(45982, 10000);
254 gcptmpl rapidXY(stockXwidth/8, 0);
255 gcptmpl cutline(gcp.xpos(), gcp.ypos(), -(stockZthickness*7/8));
256 gcptmpl cutlinedxfgc(gcp.xpos(), -stockYheight/2, -(stockZthickness*7/8));
257 gcptmpl
258 gcptmpl rapidZ(retractheight);
259 gcptmpl toolchange(204, 10000);
260 gcptmpl rapidXY(stockXwidth*0.3125, 0);
261 gcptmpl cutline(gcp.xpos(), gcp.ypos(), -(stockZthickness*7/8));
262 gcptmpl cutlinedxfgc(gcp.xpos(), -stockYheight/2, -(stockZthickness*7/8));
263 gcptmpl
264 gcptmpl rapidZ(retractheight);
265 gcptmpl toolchange(502, 10000);
266 gcptmpl rapidXY(stockXwidth*0.375, 0);
267 gcptmpl cutline(gcp.xpos(), gcp.ypos(), -4.24);
268 gcptmpl cutlinedxfgc(gcp.xpos(), -stockYheight/2, -4.24);
269 gcptmpl
270 gcptmpl rapidZ(retractheight);
271 gcptmpl toolchange(13921, 10000);
272 gcptmpl rapidXY(-stockXwidth*0.375, 0);
273 gcptmpl cutline(gcp.xpos(), gcp.ypos(), -stockZthickness/2);
274 gcptmpl cutlinedxfgc(gcp.xpos(), -stockYheight/2, -stockZthickness/2);
275 gcptmpl
276 gcptmpl rapidZ(retractheight);
277 gcptmpl gcp.toolchange(56142, 10000);
278 gcptmpl gcp.rapidXY(-stockXwidth/2, -(stockYheight/2+0.508/2));
279 gcptmpl cutlineZgcfeed(-1.531, plunge);
280 gcptmpl //cutline(gcp.xpos(), gcp.ypos(), -1.531);
281 gcptmpl cutlinedxfgc(stockXwidth/2+0.508/2, -(stockYheight/2+0.508/2),
    -1.531);
282 gcptmpl
283 gcptmpl rapidZ(retractheight);
284 gcptmpl //#gcp.toolchange(56125, 10000)
285 gcptmpl cutlineZgcfeed(-1.531, plunge);
286 gcptmpl //toolpaths.append(gcp.cutline(gcp.xpos(), gcp.ypos(), -1.531))
287 gcptmpl cutlinedxfgc(stockXwidth/2+0.508/2, (stockYheight/2+0.508/2),
    -1.531);
288 gcptmpl
289 gcptmpl stockandtoolpaths();
290 gcptmpl //stockwotoolpaths();
291 gcptmpl //outputtoolpaths();
292 gcptmpl
293 gcptmpl //makecube(3, 2, 1);
294 gcptmpl
295 gcptmpl //instantiatecube();
296 gcptmpl
297 gcptmpl closegcodefile();
298 gcptmpl closedxffiles();
299 gcptmpl closedxffile();

```

Which generates a 3D model which previews in OpenSCAD as:



3 *gcodepreview*

This library for PythonSCAD works by using Python code as a back-end so as to persistently store and access variables, and to write out files while both modeling the motion of a 3-axis CNC machine (note that at least a 4th additional axis may be worked up as a future option and supporting the work-around of two-sided (flip) machining by using an imported file as the Stock or preserving state and affording a second operation seems promising) and if desired, writing out DXF and/or G-code files (as opposed to the normal technique of rendering to a 3D model and writing out an STL or STEP or other model format and using a traditional CAM application). There are multiple modes for this, doing so may require at least two files:

- A Python file: *gcodepreview.py* (*gcpy*) — this has variables in the traditional sense which are used for tracking machine position and so forth. Note that where it is placed/loaded from will depend on whether it is imported into a Python file:

```
import gcodepreview_standalone as gcp
```

or used in an OpenSCAD file:

```
use <gcodepreview.py>
```

with an additional OpenSCAD module which allows accessing it and that there is an option for loading directly from the Github repository implemented in PythonSCAD
- An OpenSCAD file: *gcodepreview.scad* (*gcpscad*) — which uses the Python file and which is included allowing it to access OpenSCAD variables for branching

Note that this architecture requires that many OpenSCAD modules are essentially “Dispatchers” (another term is “Descriptors”) which pass information from one aspect of the environment to another, but in some instances it will be necessary to re-write Python definitions in OpenSCAD rather than calling the matching Python function directly.

In earlier versions there were several possible ways to work with the 3D models of the cuts, either directly displaying the returned 3D model when explicitly called for after storing it in a variable or calling it up as a calculation (Python command `output(<foo>)` or OpenSCAD returning a model, or calling an appropriate OpenSCAD command), however as-of v0.9 the tool movements are modeled as lists of `hull()` operations which must be processed as such and are differenced from the stock. The templates set up these options as noted, and ensure that `True == true`.

PYTHON CODING CONSIDERATIONS: Python style may be checked using a tool such as: <https://www.codewof.co.nz/style/python3/>. Not all conventions will necessarily be adhered to — limiting line length in particular conflicts with the flexibility of Literate Programming. Note that `numpydoc`-style docstrings will be added to help define the functionality of each defined module in Python. <https://numpydoc.readthedocs.io/en/latest/>.

3.1 Module Naming Convention

The original implementation required three files and used a convention for prefacing commands with `o` or `p`, but this requirement was obviated in the full Python re-write. The current implementation depends upon the class being instantiated as *gcp* as a sufficient differentiation between the Python and the OpenSCAD versions of commands which will otherwise share the same name.

Number will be abbreviated as `num` rather than `no`, and the short form will be used internally for variable names, while the complete word will be used in commands.

In some instances, `the` will be used as a prefix.

Tool `#s` where used will be the first argument where possible — this makes it obvious if they are not used — the negative consideration, that it then doesn’t allow for a usage where a `DEFAULT` tool is used is not an issue since the command `currenttoolnumber()` may be used to access that number, and is arguably the preferred mechanism. An exception is when there are multiple tool `#s` as when opening a file — collecting them all at the end is a more straight-forward approach.

In natural languages such as English, there is an order to various parts of speech such as adjectives — since various prefixes and suffixes will be used for module names, having a consistent ordering/usage will help in consistency and make expression clearer. The ordering should be: sequence (if necessary), action, function, parameter, filetype, and where possible a hierarchy of large/general to small/specific should be maintained.

- Both prefix and suffix
 - `dxf` (action (write out to DXF file), filetype)
- Prefixes
 - `generate` (Boolean) — used to identify which types of actions will be done (note that in the interest of brevity the check for this will be deferred until the last possible moment, see below)
 - `write` (action) — used to write to files, will include a check for the matching `generate` command, which being `true` will cause the write to the file to actually transpire
 - `cut` (action — create tool movement removing volume from 3D object)
 - `rapid` (action — create tool movement of 3D object so as to show any collision or rubbing)

- open (action (file))
 - close (action (file))
 - set (action/function) — note that the matching get is implicit in functions which return variables, e.g., xpos()
 - current
- Nouns (shapes)
 - arc
 - line
 - rectangle
 - circle
- Suffixes
 - feed (parameter)
 - gcode/gc (filetype)
 - pos — position
 - tool
 - loop
 - CC/CW
 - number/num — note that num is used internally for variable names, while number will be used for module/function names, making it straight-forward to ensure that functions and variables have different names for purposes of scope

Further note that commands which are implicitly for the generation of G-code, such as toolchange() will omit gc for the sake of conciseness.

In particular, this means that the basic cut... and associated commands exist (or potentially exist) in the following forms and have matching versions which may be used when programming in Python or OpenSCAD:

	line			arc		
	cut	dxf	gcode	cut	dxf	gcode
cut	cutline		cutlinegc	cutarc		cutarcgc
dxf	cutlinedxf	dxfline		cutarcdxf	dxfarcdxf	
gcode	cutlinegc		linegc	cutarcgc		arcgc
	cutlinedxfgc			cutarcdxfgc		

Note that certain commands (dxflinegc, dxfarccgc, linegc, arccgc) are either redundant or unlikely to be needed, and will most likely not be implemented (it seems contradictory that one would write out a move command to a G-code file without making that cut in the 3D preview). Note that there may be additional versions as required for the convenience of notation or cutting, in particular, a set of cutarc<quadrant><direction>gc commands was warranted during the initial development of arc-related commands.

A further consideration is that when processing G-code it is typical for a given command to be minimal and only include the axis of motion for the end-position, so for each of the above which is likely to appear in a .nc file, it will be necessary to have a matching command for the combinatorial possibilities, hence:

cutlineXYZ	cutlineXYZwithfeed
cutlineXY	cutlineXYwithfeed
cutlineXZ	cutlineXZwithfeed
cutlineYZ	cutlineYZwithfeed
cutlineX	cutlineXwithfeed
cutlineY	cutlineYwithfeed
cutlineZ	cutlineZwithfeed

Principles for naming modules (and variables):

- minimize use of underscores (for convenience sake, underscores are not used for index entries)
- identify which aspect of the project structure is being worked with (cut(ting), dxf, gcode, tool, etc.) note the gcodepreview class which will normally be imported as gcp so that module <foo> will be called as gcp.<foo> from Python and by the same <foo> in OpenSCAD

The following commands for various shapes either have been implemented (monospace) or have not yet been implemented, but likely will need to be (regular type):

- rectangle
 - cutrectangle
 - cutrectangleround

Another consideration is that all commands which write files will check to see if a given filetype is enabled or no, since that check is deferred to the last as noted above for the sake of conciseness.

There are multiple modes for programming PythonSCAD:

- Python — in gcodepreview this allows writing out dxf files
- OpenSCAD — see: <https://openscad.org/documentation.html>
- Programming in OpenSCAD with variables and calling Python — this requires 3 files and was originally used in the project as written up at: https://github.com/WillAdams/gcodepreview/blob/main/gcodepreview-openscad_0_6.pdf (for further details see below, notably various commented out lines in the source .tex file)
- Programming in OpenSCAD and calling Python where all variables as variables are held in Python classes (this is the technique used as of v0.8)
- Programming in Python and calling OpenSCAD — https://old.reddit.com/r/OpenPythonSCAD/comments/1heczmi/finally_using_scad_modules/

For reference, structurally, when developing OpenSCAD commands which make use of Python variables this was rendered as:

The user-facing module is \DescribeRoutine{FOOBAR}

```
\lstset{firstnumber=\thegcpscad}
\begin{writecode}{a}{gcodepreview.scad}{scad}
module FOOBAR(...) {
    oFOOBAR(...);
}
```

```
\end{writecode}
\addtocounter{gcpscad}{4}
```

which calls the internal OpenSCAD Module \DescribeSubroutine{FOOBAR}{oFOOBAR}

```
\begin{writecode}{a}{pygcodepreview.scad}{scad}
module oFOOBAR(...) {
    pFOOBAR(...);
}
```

```
\end{writecode}
\addtocounter{pyscad}{4}
```

which in turn calls the internal Python definition \DescribeSubroutine{FOOBAR}{pFOOBAR}

```
\lstset{firstnumber=\thegcpy}
\begin{writecode}{a}{gcodepreview.py}{python}
def pFOOBAR (...)
    ...
```

```
\end{writecode}
\addtocounter{gcpy}{3}
```

Further note that this style of definition might not have been necessary for some later modules since they are in turn calling internal modules which already use this structure.

Lastly note that this style of programming was abandoned in favour of object-oriented dot notation for versions after v0.6 (see below) and that this technique was extended to class nested within another class.

3.1.1 Parameters and Default Values

Ideally, there would be *no* hard-coded values — every value used for calculation will be parameterized, and subject to control/modification. Fortunately, Python affords a feature which specifically addresses this, optional arguments with default values:

<https://stackoverflow.com/questions/9539921/how-do-i-define-a-function-with-optional-arguments>

In short, rather than hard-code numbers, for example in loops, they will be assigned as default values, and thus afford the user/programmer the option of changing them when the module is called.

3.2 Implementation files and gcodepreview class

Each file will begin with a comment indicating the file type and further notes/comments on usage where appropriate:

```

1 gcpy #!/usr/bin/env python
2 gcpy #icon "C:\Program Files\PythonSCAD\bin\openscad.exe" --trust-python
3 gcpy #Currently tested with https://www.pythonscad.org/downloads/
   PythonSCAD_nolibfive-2025.06.04-x86-64-Installer.exe and Python
   3.11
4 gcpy #gcodepreview 0.9, for use with PythonSCAD,
5 gcpy #if using from PythonSCAD using OpenSCAD code, see gcodepreview.
   scad

6 gcpy
7 gcpy import sys
8 gcpy
9 gcpy # add math functions (sqrt)
10 gcpy import math
11 gcpy
12 gcpy # getting openscad functions into namespace
13 gcpy #https://github.com/gsohler/openscad/issues/39
14 gcpy try:
15 gcpy     from openscad import *
16 gcpy except ModuleNotFoundError as e:
17 gcpy     print("OpenSCAD module not loaded.")
18 gcpy
19 gcpy def pygcpversion():
20 gcpy     thegcpversion = 0.9
21 gcpy     return thegcpversion

```

The OpenSCAD file must use the Python file (note that some test/example code is commented out):

```

1 gcpscad #!/OpenSCAD
2 gcpscad
3 gcpscad //gcodepreview version 0.8
4 gcpscad //
5 gcpscad //used via include <gcodepreview.scad>;
6 gcpscad //
7 gcpscad
8 gcpscad use <gcodepreview.py>
9 gcpscad
10 gcpscad module gcpversion(){
11 gcpscad echo(pygcpversion());
12 gcpscad }
13 gcpscad
14 gcpscad //function myfunc(var) = gcp.myfunc(var);
15 gcpscad //
16 gcpscad //function getvv() = gcp.getvv();
17 gcpscad //
18 gcpscad //module makecube(xdim, ydim, zdim){
19 gcpscad //gcp.makecube(xdim, ydim, zdim);
20 gcpscad //}
21 gcpscad //
22 gcpscad //module placecube(){
23 gcpscad //gcp.placecube();
24 gcpscad //}
25 gcpscad //
26 gcpscad //module instantiatecube(){
27 gcpscad //gcp.instantiatecube();
28 gcpscad //}
29 gcpscad //

```

If all functions are to be handled within Python, then they will need to be gathered into a class which contains them and which is initialized so as to define shared variables and initial program state, and then there will need to be objects/commands for each aspect of the program, each of which will utilise needed variables and will contain appropriate functionality. Note that they will be divided between mandatory and optional functions/variables/objects:

- Mandatory
 - stocksetup:
 - * stockXwidth, stockYheight, stockZthickness, zeroheight, stockzero, retractheight
 - gcpfiles:
 - * basefilename, generatedxf, generategcode
 - largesquaretool:

- * large_square_tool_num, toolradius, plunge, feed, speed
- currenttoolnum
 - * endmilltype
 - * diameter
 - * flute
 - * shaftdiameter
 - * shaftheight
 - * shaftlength
 - * toolnumber
 - * cutcolor
 - * rapidcolor
 - * shaftcolor
- Optional
 - smallsquaretool:
 - * small_square_tool_num, small_square_ratio
 - largeballtool:
 - * large_ball_tool_num, large_ball_ratio
 - largeVtool:
 - * large_V_tool_num, large_V_ratio
 - smallballtool:
 - * small_ball_tool_num, small_ball_ratio
 - smallVtool:
 - * small_V_tool_num, small_V_ratio
 - DTtool:
 - * DT_tool_num, DT_ratio
 - KHtool:
 - * KH_tool_num, KH_ratio
 - Roundovertool:
 - * Roundover_tool_num, RO_ratio
 - mistool:
 - * MISC_tool_num, MISC_ratio

gcodepreview The class which is defined is gcodepreview which begins with the init method which allows
init passing in and defining the variables which will be used by the other methods in this class. Part
of this includes handling various definitions for Boolean values.

```
23 gcpy class gcodepreview:
24 gcpy
25 gcpy     def __init__(self,
26 gcpy                 generategcode = False,
27 gcpy                 generatedxf = False,
28 gcpy                 gcpfa = 2,
29 gcpy                 gcpfs = 0.125,
30 gcpy                 steps = 10
31 gcpy                 ):
32 gcpy         """
33 gcpy         Initialize gcodepreview object.
34 gcpy
35 gcpy         Parameters
36 gcpy         -----
37 gcpy         generategcode : boolean
38 gcpy                        Enables writing out G-code.
39 gcpy         generatedxf   : boolean
40 gcpy                        Enables writing out DXF file(s).
41 gcpy
42 gcpy         Returns
43 gcpy         -----
44 gcpy         object
45 gcpy         The initialized gcodepreview object.
46 gcpy         """
47 gcpy         if generategcode == 1:
48 gcpy             self.generategcode = True
49 gcpy         elif generategcode == 0:
50 gcpy             self.generategcode = False
51 gcpy         else:
52 gcpy             self.generategcode = generategcode
```

```

53 gcpy          if generatedxf == 1:
54 gcpy              self.generatedxf = True
55 gcpy          elif generatedxf == 0:
56 gcpy              self.generatedxf = False
57 gcpy          else:
58 gcpy              self.generatedxf = generatedxf
59 gcpy # unless multiple dxfs are enabled, the check for them is of course
        False
60 gcpy          self.generatedxfs = False
61 gcpy # set up 3D previewing parameters
62 gcpy          fa = gcpfa
63 gcpy          fs = gcpfs
64 gcpy          self.steps = steps
65 gcpy # initialize the machine state
66 gcpy          self.mc = "Initialized"
67 gcpy          self.mpx = float(0)
68 gcpy          self.mpy = float(0)
69 gcpy          self.mpz = float(0)
70 gcpy          self.tpz = float(0)
71 gcpy # initialize the toolpath state
72 gcpy          self.retractheight = 5
73 gcpy # initialize the DEFAULT tool
74 gcpy          self.currenttoolnum = 102
75 gcpy          self.endmilltype = "square"
76 gcpy          self.diameter = 3.175
77 gcpy          self.flute = 12.7
78 gcpy          self.shaftdiameter = 3.175
79 gcpy          self.shaftheight = 12.7
80 gcpy          self.shaftlength = 19.5
81 gcpy          self.toolnumber = "100036"
82 gcpy          self.cutcolor = "green"
83 gcpy          self.rapidcolor = "orange"
84 gcpy          self.shaftcolor = "red"
85 gcpy # the variables for holding 3D models must be initialized as empty
        lists so as to ensure that only append or extend commands are
        used with them
86 gcpy          self.rapids = []
87 gcpy          self.toolpaths = []
88 gcpy
89 gcpy #      def myfunc(self, var):
90 gcpy #          self.vv = var * var
91 gcpy #          return self.vv
92 gcpy #
93 gcpy #      def getvv(self):
94 gcpy #          return self.vv
95 gcpy #
96 gcpy #      def checkint(self):
97 gcpy #          return self.mc
98 gcpy #
99 gcpy #      def makecube(self, xdim, ydim, zdim):
100 gcpy #          self.c=cube([xdim, ydim, zdim])
101 gcpy #
102 gcpy #      def placecube(self):
103 gcpy #          show(self.c)
104 gcpy #
105 gcpy #      def instantiatecube(self):
106 gcpy #          return self.c

```

3.2.1 Position and Variables

In modeling the machine motion and G-code it will be necessary to have the machine track several variables for machine position, the current tool and its parameters, and the current depth in the current toolpath. This will be done using paired functions (which will set and return the matching variable) and a matching variable.

The first such variables are for xyz position:

```

mpx      • mpx
mpy      • mpy
mpz      • mpz

```

Similarly, for some toolpaths it will be necessary to track the depth along the Z-axis as the toolpath is cut out, or the increment which a cut advances — this is done using an internal variable, `tpzinc`.

It will further be necessary to have a variable for the current tool:

```

currenttoolnum      • currenttoolnum

```

Note that the `currenttoolnum` variable should always be accessed and used for any specification

of a tool, being read in whenever a tool is to be made use of, or a parameter or aspect of the tool needs to be used in a calculation.

In early versions, a 3D model of the tool was available as `currenttool` itself and used where appropriate, but in v0.9, this was changed to using lists for concatenating the hulled shapes of tool movements, so the module, `toolmovement` which given begin/end position returns the appropriate shape(s) as a list.

It will be necessary to have Python functions (`xpos`, `ypos`, and `zpos`) which return the current values of the machine position in Cartesian coordinates:

```
xpos
ypos
zpos
108 gcpy      def xpos(self):
109 gcpy          return self.mpx
110 gcpy
111 gcpy      def ypos(self):
112 gcpy          return self.mpy
113 gcpy
114 gcpy      def zpos(self):
115 gcpy          return self.mpz
```

Wrapping these in OpenSCAD functions allows use of this positional information from OpenSCAD:

```
30 gcpscad function xpos() = gcp.xpos();
31 gcpscad
32 gcpscad function ypos() = gcp.ypos();
33 gcpscad
34 gcpscad function zpos() = gcp.zpos();
```

and in turn, functions which set the positions: `setxpos`, `setypos`, and `setzpos`.

```
setxpos
setypos
setzpos
117 gcpy      def setxpos(self, newxpos):
118 gcpy          self.mpx = newxpos
119 gcpy
120 gcpy      def setypos(self, newypos):
121 gcpy          self.mpy = newypos
122 gcpy
123 gcpy      def setzpos(self, newzpos):
124 gcpy          self.mpz = newzpos
```

Using the `set...` routines will afford a single point of control if specific actions are found to be contingent on changes to these positions.

3.2.2 Initial Modules

Initializing the machine state requires zeroing out the three machine position variables:

- `mpx`
- `mpy`
- `mpz`

Rather than a specific command for this, the code will be in-lined where appropriate (note that if machine initialization becomes sufficiently complex to warrant it, then a suitable command will need to be coded). Note that the variables are declared in the `__init__` of the class.

The `toolmovement` class requires that the tool be defined in terms of `endmilltype`, `diameter`, `endmilltype` flute (length), `ra` (radius or angle depending on context), and `tip`, and in turn defines the tool number as described below. An interface which calls this routine based on tool number will allow a return to the previous style of usage.

There will be two variables to record `toolmovement`, `rapids` and `toolpaths`. Initialized as empty lists, toolmovements will be extended to the lists.

3.2.2.1 setupstock The first such setup subroutine is `gcodepreview` `setupstock` which is appropriately enough, to set up the stock, and perform other initializations — initially, the only thing done in Python was to set the value of the persistent (Python) variables (see `initializemachinestate()` above), but the rewritten standalone version handles all necessary actions.

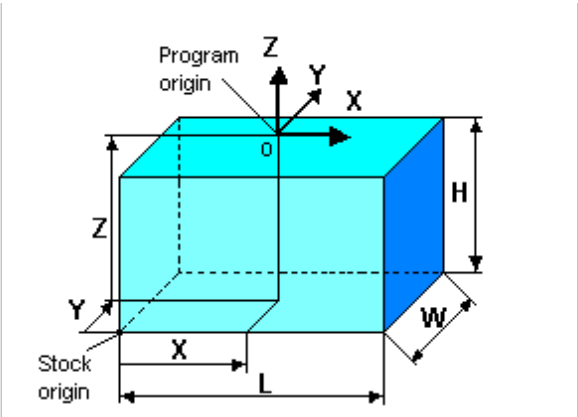
Since part of a class, it will be called as `gcp.setupstock`. It requires that the user set parameters for stock dimensions and so forth, and will create comments in the G-code (if generating that file is enabled) which incorporate the stock dimensions and its position relative to the zero as set relative to the stock.

```
126 gcpy      def setupstock(self, stockXwidth,
127 gcpy          stockYheight,
128 gcpy          stockZthickness,
```

```
129 gcpy          zeroheight ,
130 gcpy          stockzero ,
131 gcpy          retractheight):
132 gcpy          """
133 gcpy          Set up blank/stock for material and position/zero.
134 gcpy
135 gcpy          Parameters
136 gcpy          -----
137 gcpy          stockXwidth :    float
138 gcpy                        X extent/dimension
139 gcpy          stockYheight :  float
140 gcpy                        Y extent/dimension
141 gcpy          stockZthickness : boolean
142 gcpy                        Z extent/dimension
143 gcpy          zeroheight :    string
144 gcpy                        Top or Bottom, determines if Z extent will
                                be positive or negative
145 gcpy          stockzero :     string
146 gcpy                        Lower-Left, Center-Left, Top-Left, Center,
                                determines XY position of stock
147 gcpy          retractheight : float
148 gcpy                        Distance which tool retracts above surface
                                of stock.
149 gcpy
150 gcpy          Returns
151 gcpy          -----
152 gcpy          none
153 gcpy          """
154 gcpy          self.stockXwidth = stockXwidth
155 gcpy          self.stockYheight = stockYheight
156 gcpy          self.stockZthickness = stockZthickness
157 gcpy          self.zeroheight = zeroheight
158 gcpy          self.stockzero = stockzero
159 gcpy          self.retractheight = retractheight
160 gcpy          self.stock = cube([stockXwidth, stockYheight,
                                stockZthickness])
```

zeroheight A series of if statements parse the zeroheight (Z-axis) and stockzero (X- and Y-axes) parameters so as to place the stock in place and suitable G-code comments are added for CutViewer.
stockzero The CutViewer comments are in the form:

(STOCK/BLOCK, Length, Width, Height, Origin X, Origin Y, Origin Z)



```
162 gcpy          if self.zeroheight == "Top":
163 gcpy              if self.stockzero == "Lower-Left":
164 gcpy                  self.stock = self.stock.translate([0, 0, -self.
                                stockZthickness])
165 gcpy              if self.generategcode == True:
166 gcpy                  self.writegc("(stockMin:0.00mm,␣0.00mm,␣-", str
                                (self.stockZthickness), "mm)")
167 gcpy                  self.writegc("(stockMax:", str(self.stockXwidth
                                ), "mm,␣", str(stockYheight), "mm,␣0.00mm)")
168 gcpy                  self.writegc("(STOCK/BLOCK,␣", str(self.
                                stockXwidth), ",␣", str(self.stockYheight),
                                ",␣", str(self.stockZthickness), ",␣0.00,␣
                                0.00,␣", str(self.stockZthickness), ")")
169 gcpy              if self.stockzero == "Center-Left":
170 gcpy                  self.stock = self.stock.translate([0, -stockYheight
                                / 2, -stockZthickness])
171 gcpy              if self.generategcode == True:
```

```

172 gcpy          self.writegc("(stockMin:0.00mm,␣-", str(self.
                    stockYheight/2), "mm,␣-", str(self.
                    stockZthickness), "mm)")
173 gcpy          self.writegc("(stockMax:", str(self.stockXwidth
                    ), "mm,␣", str(self.stockYheight/2), "mm,␣
                    0.00mm)")
174 gcpy          self.writegc("(STOCK/BLOCK,␣", str(self.
                    stockXwidth), ",␣", str(self.stockYheight),
                    ",␣", str(self.stockZthickness), ",␣0.00,␣",
                    str(self.stockYheight/2), ",␣", str(self.
                    stockZthickness), ")");
175 gcpy          if self.stockzero == "Top-Left":
176 gcpy              self.stock = self.stock.translate([0, -self.
                    stockYheight, -self.stockZthickness])
177 gcpy          if self.generategcode == True:
178 gcpy              self.writegc("(stockMin:0.00mm,␣-", str(self.
                    stockYheight), "mm,␣-", str(self.
                    stockZthickness), "mm)")
179 gcpy          self.writegc("(stockMax:", str(self.stockXwidth
                    ), "mm,␣0.00mm,␣0.00mm)")
180 gcpy          self.writegc("(STOCK/BLOCK,␣", str(self.
                    stockXwidth), ",␣", str(self.stockYheight),
                    ",␣", str(self.stockZthickness), ",␣0.00,␣",
                    str(self.stockYheight), ",␣", str(self.
                    stockZthickness), ")")
181 gcpy          if self.stockzero == "Center":
182 gcpy              self.stock = self.stock.translate([-self.
                    stockXwidth / 2, -self.stockYheight / 2, -self.
                    stockZthickness])
183 gcpy          if self.generategcode == True:
184 gcpy              self.writegc("(stockMin:␣-", str(self.
                    stockXwidth/2), ",␣-", str(self.stockYheight
                    /2), "mm,␣-", str(self.stockZthickness), "mm
                    )")
185 gcpy          self.writegc("(stockMax:", str(self.stockXwidth
                    /2), "mm,␣", str(self.stockYheight/2), "mm,␣
                    0.00mm)")
186 gcpy          self.writegc("(STOCK/BLOCK,␣", str(self.
                    stockXwidth), ",␣", str(self.stockYheight),
                    ",␣", str(self.stockZthickness), ",␣", str(
                    self.stockXwidth/2), ",␣", str(self.
                    stockYheight/2), ",␣", str(self.
                    stockZthickness), ")")
187 gcpy          if self.zeroheight == "Bottom":
188 gcpy              if self.stockzero == "Lower-Left":
189 gcpy                  self.stock = self.stock.translate([0, 0, 0])
190 gcpy                  if self.generategcode == True:
191 gcpy                      self.writegc("(stockMin:0.00mm,␣0.00mm,␣0.00mm
                    )")
192 gcpy          self.writegc("(stockMax:", str(self.
                    stockXwidth), "mm,␣", str(self.stockYheight
                    ), "mm,␣", str(self.stockZthickness), "mm")
                    )
193 gcpy          self.writegc("(STOCK/BLOCK,␣", str(self.
                    stockXwidth), ",␣", str(self.stockYheight),
                    ",␣", str(self.stockZthickness), ",␣0.00,␣
                    0.00,␣0.00)")
194 gcpy          if self.stockzero == "Center-Left":
195 gcpy              self.stock = self.stock.translate([0, -self.
                    stockYheight / 2, 0])
196 gcpy          if self.generategcode == True:
197 gcpy              self.writegc("(stockMin:0.00mm,␣-", str(self.
                    stockYheight/2), "mm,␣0.00mm)")
198 gcpy          self.writegc("(stockMax:", str(self.stockXwidth
                    ), "mm,␣", str(self.stockYheight/2), "mm,␣-",
                    str(self.stockZthickness), "mm)")
199 gcpy          self.writegc("(STOCK/BLOCK,␣", str(self.
                    stockXwidth), ",␣", str(self.stockYheight),
                    ",␣", str(self.stockZthickness), ",␣0.00,␣",
                    str(self.stockYheight/2), ",␣0.00mm)");
200 gcpy          if self.stockzero == "Top-Left":
201 gcpy              self.stock = self.stock.translate([0, -self.
                    stockYheight, 0])
202 gcpy          if self.generategcode == True:
203 gcpy              self.writegc("(stockMin:0.00mm,␣-", str(self.
                    stockYheight), "mm,␣0.00mm)")
204 gcpy          self.writegc("(stockMax:", str(self.stockXwidth
                    ), "mm,␣0.00mm,␣", str(self.stockZthickness)

```

```

    , "mm)")
205 gcpy          self.writegc("(STOCK/BLOCK,␣", str(self.
                    stockXwidth), "␣", str(self.stockYheight),
                    "␣", str(self.stockZthickness), "␣0.00␣",
                    str(self.stockYheight), "␣0.00)")
206 gcpy          if self.stockzero == "Center":
207 gcpy          self.stock = self.stock.translate([-self.
                    stockXwidth / 2, -self.stockYheight / 2, 0])
208 gcpy          if self.generategcode == True:
209 gcpy          self.writegc("(stockMin:␣-", str(self.
                    stockXwidth/2), "␣-", str(self.stockYheight
                    /2), "mm␣0.00mm)")
210 gcpy          self.writegc("(stockMax:", str(self.stockXwidth
                    /2), "mm␣", str(self.stockYheight/2), "mm␣",
                    str(self.stockZthickness), "mm)")
211 gcpy          self.writegc("(STOCK/BLOCK,␣", str(self.
                    stockXwidth), "␣", str(self.stockYheight),
                    "␣", str(self.stockZthickness), "␣", str(
                    self.stockXwidth/2), "␣", str(self.
                    stockYheight/2), "␣0.00)")
212 gcpy          if self.generategcode == True:
213 gcpy          self.writegc("G90");
214 gcpy          self.writegc("G21");
```

Note that while the #102 is declared as a default tool, while it was originally necessary to call a tool change after invoking `setupstock`, in the 2024.09.03 version of PythonSCAD this requirement went away when an update which interfered with persistently setting a variable directly was fixed. The `setupstock` command is required if working with a 3D project, creating the block of stock which the following toolpath commands will cut away. Note that since Python in OpenPython-SCAD defers output of the 3D model, it is possible to define it once, then set up all the specifics for each possible positioning of the stock in terms of origin.

The OpenSCAD version is simply a descriptor:

```

36 gcpyscad module setupstock(stockXwidth, stockYheight, stockZthickness,
                                zeroheight, stockzero, retractheight) {
37 gcpyscad     gcp.setupstock(stockXwidth, stockYheight, stockZthickness,
                                zeroheight, stockzero, retractheight);
38 gcpyscad }
```

If processing G-code, the parameters passed in are necessarily different, and there is of course, no need to write out G-code.

```

216 gcpy      def setupcuttingarea(self, sizeX, sizeY, sizeZ, extentleft,
                                extentfb, extentd):
217 gcpy      #      self.initializemachinestate()
218 gcpy      c=cube([sizeX,sizeY,sizeZ])
219 gcpy      c = c.translate([extentleft,extentfb,extentd])
220 gcpy      self.stock = c
221 gcpy      self.toolpaths = []
222 gcpy      return c
```

3.2.3 Adjustments and Additions

For certain projects and toolpaths it will be helpful to shift the stock, and to add additional pieces to the project.

Shifting the stock is simple:

```

224 gcpy      def shiftstock(self, shiftX, shiftY, shiftZ):
225 gcpy      self.stock = self.stock.translate([shiftX, shiftY, shiftZ
                                                ])
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```

adding stock is similar, but adds the requirement that it include options for shifting the stock:

```

227 gcpy      def addtostock(self, stockXwidth, stockYheight, stockZthickness
                                ,
228 gcpy      ,
229 gcpy      ,
230 gcpy      ,
231 gcpy      ,
232 gcpy      ,
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```



```
231 gcpy          addedpart = cube([stockXwidth, stockYheight,
                                stockZthickness])
232 gcpy          addedpart = addedpart.translate([shiftX, shiftY, shiftZ])
233 gcpy          self.stock = self.stock.union(addedpart)
```

the OpenSCAD module is a descriptor as expected:

```
44 gcpscad module addtostock(stockXwidth, stockYheight, stockZthickness,
                             shiftX, shiftY, shiftZ) {
45 gcpscad     gcp.addtostock(stockXwidth, stockYheight, stockZthickness,
                             shiftX, shiftY, shiftZ);
46 gcpscad }
```

3.3 Tools and Changes

Originally, it was necessary to return a shape so that modules which use a <variable>.union command would function as expected even when the 3D model created is stored in a variable.

Due to stack limits in OpenSCAD for the CSG tree, instead, the shapes will be stored in two variables as lists processed/created using a command `toolmovement` which will subsume all tool related functionality. As other routines need access to information about the current tool, appropriate routines will allow its variables will be queried.

The base/entry functionality has the instance being defined in terms of a basic set of variables (one of which is overloaded to serve multiple purposes, depending on the type of endmill).

Note that it will also be necessary to write out a tool description compatible with the program CutViewer as a G-code comment so that it may be used as a 3D previewer for the G-code for tool changes in G-code. Several forms are available as described below.

3.3.1 Numbering for Tools

Currently, the numbering scheme used is that of the various manufacturers of the tools, or descriptive short-hand numbers created for tools which lack such a designation (with a disclosure that the author is a Carbide 3D employee).

Creating any numbering scheme is like most things in life, a trade-off, balancing length and expressiveness/compleatness against simplicity and usability. The software application Carbide Create (as released by an employer of the main author) has a limit of six digits, which seems a reasonable length from a complexity/simplicity standpoint, but also potentially reasonably expressible.

It will be desirable to track the following characteristics and measurements, apportioned over the digits as follows:

1

2-3

4-5

6

endmill type radius/angle cutting diameter(and tip radius for tapered ball nose) cutting flute length

- 1st digit: endmill type:
 - 0 - “O”-flute
 - 1 - square
 - 2 - ball
 - 3 - V
 - 4 - bowl
 - 5 - tapered ball
 - 6 - roundover
 - 7 - thread-cutting
 - 8 - dovetail
 - 9 - other (e.g., keyhole, lollipop, or manufacturer number — if manufacturer number is used, then the 9 and any padding zeroes will be removed from the G-code or DXF when writing out file(s))
- 2nd and 3rd digits shape radius (ball/roundover) or angle (V), 2nd and 3rd digit together 10–99 indicate measurement in tenth of a millimeter. 2nd digit:
 - 0 - Imperial (00 indicates n/a or square)
 - any other value for both the 2nd and 3rd digits together indicate a metric measurement or an angle in degrees
- 3rd digit (if 2nd is 0 indicating Imperial)
 - 1 - 1/32nd
 - 2 - 1/16

- 3 - 1/8
 - 4 - 1/4
 - 5 - 5/16
 - 6 - 3/8
 - 7 - 1/2
 - 8 - 3/4
 - 9 - >1" or other
- 4th and 5th digits cutting diameter as 2nd and 3rd above except 4th digit indicates tip radius for tapered ball nose and such tooling is only represented in Imperial measure:
- 4th digit (tapered ball nose)
 - 1 - 0.01 in (this is the 0.254mm of the #501 and 502)
 - 2 - 0.015625 in (1/64th)
 - 3 - 0.0295
 - 4 - 0.03125 in (1/32nd)
 - 5 - 0.0335
 - 6 - 0.0354
 - 7 - 0.0625 in (1/16th)
 - 8 - 0.125 in (1/8th)
 - 9 - 0.25 in (1/4)
- 6th digit cutting flute length:
 - 0 - other
 - 1 - calculate based on V angle
 - 2 - 1/16
 - 3 - 1/8
 - 4 - 1/4
 - 5 - 5/16
 - 6 - 1/2
 - 7 - 3/4
 - 8 - "long reach" or greater than 3/4"
 - 9 - calculate based on radius
- or 6th digit tip diameter for roundover tooling (added to cutting diameter to arrive at actual cutting diameter — note that these values are the same as for the tip radius of the #501 and 502)
 - 1 - 0.01 in
 - 2 - 0.015625 in (1/64th)
 - 3 - 0.0295
 - 4 - 0.03125 in (1/32nd)
 - 5 - 0.0335
 - 6 - 0.0354
 - 7 - 0.0625 in (1/16th)
 - 8 - 0.125 in (1/8th)
 - 9 - 0.25 in (1/4)

Using this technique to create tool numbers for Carbide 3D tooling we arrive at:

- Square
 - #122 == 100012
 - #112 == 100024
 - #102 == 100036 (also #326 (Amana 46200-K))
 - #201 == 100047 (also #251 and #322 (Amana 46202-K))
 - #205 == 100048
 - #324 == 100048 (Amana 46170-K)

- Ball
 - #121 == 201012
 - #111 == 202024
 - #101 == 203036
 - #202 == 204047
 - #325 == 204048 (Amana 46376-K)
- V
 - #301 == 390074
 - #302 == 360071
 - #327 == 360098 (Amana RC-1148)
- Single (O) flute
 - #282 == 000204
 - #274 == 000036
 - #278 == 000047
- Tapered Ball Nose
 - #501 == 530131
 - #502 == 540131

(note that some dimensions were rounded off/approximated)

Extending that to the non-Carbide 3D tooling thus implemented:

- Dovetail
 - 814 == 814071
 - 45828 == 808071
- Keyhole Tool
 - 374 == 906043
 - 375 == 906053
 - 376 == 907040
 - 378 == 907050
- Roundover Tool
 - 56142 == 602032
 - 56125 == 603042
 - 1568 == 603032
 - 1570
 - 1572 == 604042
 - 1574
- Threadmill
 - 648 == 7
- Bowl bit
 - 45981
 - 45982
 - 1370
 - 1372

Tools which do not have calculated numbers filled in are not supported by the system as currently defined in an unambiguous fashion (instead filling in the manufacturer's tool number padded with zeros is hard-coded). Notable limitations:

- No way to indicate flute geometry beyond O-flute
- Lack of precision for metric tooling/limited support for Imperial sizes, notably, the dimensions used are scaled for smaller tooling and are not suited to larger scale tooling such as bowl bits
- No way to indicate several fairly common shapes including keyhole, lollipop, and flat-bottomed V/chamfer tools (except of course for using 9#####)

A further consideration is that it is not possible to represent tools unambiguously, so that given a tool definition it is possible to derive the manufacturer's tool number, *e.g.*,

```
self.currenttoolshape = self.toolshapes("square", 3.175, 12.7)
```

representing three different tools (Carbide 3D #201 (upcut), #251 (downcut), and #322 (Amana 46202-K)). Affording some sort of hinting to the user may be warranted, or a mechanism to allow specifying a given manufacturer tool as part of setting up a job.

A more likely scheme is that manufacturer tool numbers will be used to identify tooling, the generated number will be used internally, then the saved manufacturer number will be exported to the G-code file, or used when generating a DXF filename for a given set of tool movements.

```
235 gcpy      def currenttoolnumber(self):
236 gcpy          return(self.currenttoolnum)
```

toolchange The toolchange command will need to set several variables.
Mandatory variables include:

- endmilltype
 - O-flute
 - square
 - ball
 - V
 - keyhole
 - dovetail
 - roundover
 - tapered ball
- diameter
- flute

and depending on the tool geometry, several additional variables will be necessary (usually derived from self.ra):

- radius
- angle

an optional setting of a toolnumber may be useful in the future.

tool number 3.3.1.1 toolchange This command accepts a tool number and assigns its characteristics as pa-
toolchange rameters. It then applies the appropriate commands for a toolchange. Note that it is expected that this code will be updated as needed when new tooling is introduced as additional modules which require specific tooling are added.

Note that the comments written out in G-code correspond to those used by the G-code pre-viewing tool CutViewer (which is unfortunately, no longer readily available). Similarly, the G-code pre-viewing functionality in this library expects that such comments will be in place so as to model the stock.

A further concern is that early versions often passed the tool into a module using a parameter. That ceased to be necessary in the 2024.09.03 version of PythonSCAD, and all modules should read the tool # from currenttoolnumber().

Note that there are many varieties of tooling and not all will be directly supported, and that at need, additional tool shape support may be added under misc.

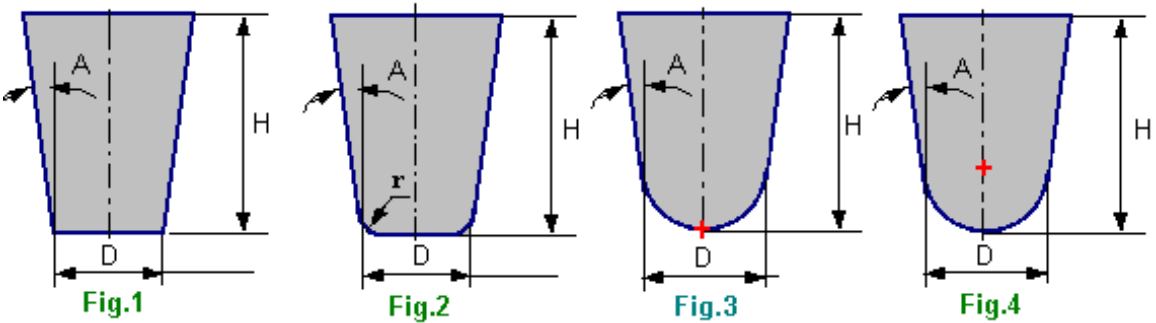
The original implementation created the model for the tool at the current position, and a duplicate at the end position, wrapping the twain for each end of a given movement in a hull() command and then applying a union. This approach will not work within Python, so it will be necessary to instead assign and select the tool as part of the toolmovement command.

```
238 gcpy      def toolchange(self, tool_number, speed = 10000):
239 gcpy          self.currenttoolnum = tool_number
240 gcpy
241 gcpy          if (self.generategcode == True):
242 gcpy              self.writegc("(Toolpath)")
243 gcpy              self.writegc("M05")
```

toolchange The Python definition for toolchange requires the tool number (used to write out the G-code comment description for CutViewer and also expects the speed for the current tool since this is passed into the G-code tool change command as part of the spindle on command. A simple if-then structure, the variables necessary for defining the toolshape are (re)defined each time the
toolmovement command is called so that they may be used by the command toolmovement for actually modeling the shapes and the path and the resultant material removal.

3.3.1.2 Square (including O-flute) The CutViewer values include:

TOOL/MILL, Diameter, Corner radius, Height, Taper Angle



```
245 gcpy      if (tool_number == 201): #201/251/322 (Amana 46202-K) ==
100047
246 gcpy      self.writegc("(TOOL/MILL,□6.35,□0.00,□0.00,□0.00)")
247 gcpy      self.endmilltype = "square"
248 gcpy      self.diameter = 6.35
249 gcpy      self.flute = 19.05
250 gcpy      self.shaftdiameter = 6.35
251 gcpy      self.shaftheight = 19.05
252 gcpy      self.shaftlength = 20.0
253 gcpy      self.toolnumber = "100047"
254 gcpy      elif (tool_number == 102): #102/326 == 100036
255 gcpy      self.writegc("(TOOL/MILL,□3.175,□0.00,□0.00,□0.00)")
256 gcpy      self.endmilltype = "square"
257 gcpy      self.diameter = 3.175
258 gcpy      self.flute = 12.7
259 gcpy      self.shaftdiameter = 3.175
260 gcpy      self.shaftheight = 12.7
261 gcpy      self.shaftlength = 20.0
262 gcpy      self.toolnumber = 100036
263 gcpy      elif (tool_number == 112): #112 == 100024
264 gcpy      self.writegc("(TOOL/MILL,□1.5875,□0.00,□0.00,□0.00)")
265 gcpy      self.endmilltype = "square"
266 gcpy      self.diameter = 1.5875
267 gcpy      self.flute = 6.35
268 gcpy      self.shaftdiameter = 3.175
269 gcpy      self.shaftheight = 6.35
270 gcpy      self.shaftlength = 12.0
271 gcpy      self.toolnumber = "100024"
272 gcpy      elif (tool_number == 122): #122 == 100012
273 gcpy      self.writegc("(TOOL/MILL,□0.79375,□0.00,□0.00,□0.00)")
274 gcpy      self.endmilltype = "square"
275 gcpy      self.diameter = 0.79375
276 gcpy      self.flute = 1.5875
277 gcpy      self.shaftdiameter = 3.175
278 gcpy      self.shaftheight = 1.5875
279 gcpy      self.shaftlength = 12.0
280 gcpy      self.toolnumber = "100012"
281 gcpy      elif (tool_number == 324): #324 (Amana 46170-K) == 100048
282 gcpy      self.writegc("(TOOL/MILL,□6.35,□0.00,□0.00,□0.00)")
283 gcpy      self.endmilltype = "square"
284 gcpy      self.diameter = 6.35
285 gcpy      self.flute = 22.225
286 gcpy      self.shaftdiameter = 6.35
287 gcpy      self.shaftheight = 22.225
288 gcpy      self.shaftlength = 20.0
289 gcpy      self.toolnumber = "100048"
290 gcpy      elif (tool_number == 205): #205 == 100048
291 gcpy      self.writegc("(TOOL/MILL,□6.35,□0.00,□0.00,□0.00)")
292 gcpy      self.endmilltype = "square"
293 gcpy      self.diameter = 6.35
294 gcpy      self.flute = 25.4
295 gcpy      self.shaftdiameter = 6.35
296 gcpy      self.shaftheight = 25.4
297 gcpy      self.shaftlength = 20.0
298 gcpy      self.toolnumber = "100048"
299 gcpy      #
```

Making a distinction betwixt Square and O-flute tooling may be removed from a future version.

```

300 gcpy          elif (tool_number == 282): #282 == 000204
301 gcpy            self.writegc("(TOOL/MILL,␣2.0,␣0.00,␣0.00,␣0.00)")
302 gcpy            self.endmilltype = "0-flute"
303 gcpy            self.diameter = 2.0
304 gcpy            self.flute = 6.35
305 gcpy            self.shaftdiameter = 6.35
306 gcpy            self.shaftheight = 6.35
307 gcpy            self.shaftlength = 12.0
308 gcpy            self.toolnumber = "000204"
309 gcpy          elif (tool_number == 274): #274 == 000036
310 gcpy            self.writegc("(TOOL/MILL,␣3.175,␣0.00,␣0.00,␣0.00)")
311 gcpy            self.endmilltype = "0-flute"
312 gcpy            self.diameter = 3.175
313 gcpy            self.flute = 12.7
314 gcpy            self.shaftdiameter = 3.175
315 gcpy            self.shaftheight = 12.7
316 gcpy            self.shaftlength = 20.0
317 gcpy            self.toolnumber = "000036"
318 gcpy          elif (tool_number == 278): #278 == 000047
319 gcpy            self.writegc("(TOOL/MILL,␣6.35,␣0.00,␣0.00,␣0.00)")
320 gcpy            self.endmilltype = "0-flute"
321 gcpy            self.diameter = 6.35
322 gcpy            self.flute = 19.05
323 gcpy            self.shaftdiameter = 3.175
324 gcpy            self.shaftheight = 19.05
325 gcpy            self.shaftlength = 20.0
326 gcpy            self.toolnumber = "000047"
327 gcpy          #

```

3.3.1.3 Ball nose (including tapered ball nose) Additional shapes continue the elifs...

```

328 gcpy          elif (tool_number == 202): #202 == 204047
329 gcpy            self.writegc("(TOOL/MILL,␣6.35,␣3.175,␣0.00,␣0.00)")
330 gcpy            self.endmilltype = "ball"
331 gcpy            self.diameter = 6.35
332 gcpy            self.flute = 19.05
333 gcpy            self.shaftdiameter = 6.35
334 gcpy            self.shaftheight = 19.05
335 gcpy            self.shaftlength = 20.0
336 gcpy            self.toolnumber = "204047"
337 gcpy          elif (tool_number == 101): #101 == 203036
338 gcpy            self.writegc("(TOOL/MILL,␣3.175,␣1.5875,␣0.00,␣0.00)")
339 gcpy            self.endmilltype = "ball"
340 gcpy            self.diameter = 3.175
341 gcpy            self.flute = 12.7
342 gcpy            self.shaftdiameter = 3.175
343 gcpy            self.shaftheight = 12.7
344 gcpy            self.shaftlength = 20.0
345 gcpy            self.toolnumber = "203036"
346 gcpy          elif (tool_number == 111): #111 == 202024
347 gcpy            self.writegc("(TOOL/MILL,␣1.5875,␣0.79375,␣0.00,␣0.00)"
348 gcpy              )
349 gcpy            self.endmilltype = "ball"
350 gcpy            self.diameter = 1.5875
351 gcpy            self.flute = 6.35
352 gcpy            self.shaftdiameter = 3.175
353 gcpy            self.shaftheight = 6.35
354 gcpy            self.shaftlength = 20.0
355 gcpy            self.toolnumber = "202024"
356 gcpy          elif (tool_number == 121): #121 == 201012
357 gcpy            self.writegc("(TOOL/MILL,␣3.175,␣0.79375,␣0.00,␣0.00)")
358 gcpy            self.endmilltype = "ball"
359 gcpy            self.diameter = 0.79375
360 gcpy            self.flute = 1.5875
361 gcpy            self.shaftdiameter = 3.175
362 gcpy            self.shaftheight = 1.5875
363 gcpy            self.shaftlength = 20.0
364 gcpy            self.toolnumber = "201012"
365 gcpy          elif (tool_number == 325): #325 (Amana 46376-K) == 204048
366 gcpy            self.writegc("(TOOL/MILL,␣6.35,␣3.175,␣0.00,␣0.00)")
367 gcpy            self.endmilltype = "ball"
368 gcpy            self.diameter = 6.35
369 gcpy            self.flute = 25.4
370 gcpy            self.shaftdiameter = 6.35
371 gcpy            self.shaftheight = 25.4
372 gcpy            self.shaftlength = 20.0
373 gcpy            self.toolnumber = "204048"

```

373 gcpy #

3.3.1.4 V Note that one V tool is described as an Engraver in Carbide Create. While CutViewer has specialty Tool/chamfer and Tool/drill parameters, it is possible to describe a V tool as a Tool/mill (using a very small tip radius).

```
374 gcpy         elif (tool_number == 301): #301 == 390074
375 gcpy             self.writegc("(TOOL/MILL,␣0.10,␣0.05,␣6.35,␣45.00)")
376 gcpy             self.endmilltype = "V"
377 gcpy             self.diameter = 12.7
378 gcpy             self.flute = 6.35
379 gcpy             self.angle = 90
380 gcpy             self.shaftdiameter = 6.35
381 gcpy             self.shaftheight = 6.35
382 gcpy             self.shaftlength = 20.0
383 gcpy             self.toolnumber = "390074"
384 gcpy         elif (tool_number == 302): #302 == 360071
385 gcpy             self.writegc("(TOOL/MILL,␣0.10,␣0.05,␣6.35,␣30.00)")
386 gcpy             self.endmilltype = "V"
387 gcpy             self.diameter = 12.7
388 gcpy             self.flute = 11.067
389 gcpy             self.angle = 60
390 gcpy             self.shaftdiameter = 6.35
391 gcpy             self.shaftheight = 11.067
392 gcpy             self.shaftlength = 20.0
393 gcpy             self.toolnumber = "360071"
394 gcpy         elif (tool_number == 390): #390 == 390032
395 gcpy             self.writegc("(TOOL/MILL,␣0.03,␣0.00,␣1.5875,␣45.00)")
396 gcpy             self.endmilltype = "V"
397 gcpy             self.diameter = 3.175
398 gcpy             self.flute = 1.5875
399 gcpy             self.angle = 90
400 gcpy             self.shaftdiameter = 3.175
401 gcpy             self.shaftheight = 1.5875
402 gcpy             self.shaftlength = 20.0
403 gcpy             self.toolnumber = "390032"
404 gcpy         elif (tool_number == 327): #327 (Amana RC-1148) == 360098
405 gcpy             self.writegc("(TOOL/MILL,␣0.03,␣0.00,␣13.4874,␣30.00)")
406 gcpy             self.endmilltype = "V"
407 gcpy             self.diameter = 25.4
408 gcpy             self.flute = 22.134
409 gcpy             self.angle = 60
410 gcpy             self.shaftdiameter = 6.35
411 gcpy             self.shaftheight = 22.134
412 gcpy             self.shaftlength = 20.0
413 gcpy             self.toolnumber = "360098"
414 gcpy         elif (tool_number == 323): #323 == 330041 30 degree V Amana
415 gcpy             , 45771-K
416 gcpy             self.writegc("(TOOL/MILL,␣0.10,␣0.05,␣11.18,␣15.00)")
417 gcpy             self.endmilltype = "V"
418 gcpy             self.diameter = 6.35
419 gcpy             self.flute = 11.849
420 gcpy             self.angle = 30
421 gcpy             self.shaftdiameter = 6.35
422 gcpy             self.shaftheight = 11.849
423 gcpy             self.shaftlength = 20.0
424 gcpy             self.toolnumber = "330041"
424 gcpy #
```

3.3.1.5 Keyhole Keyhole tooling will primarily be used with a dedicated toolpath.

```
425 gcpy         elif (tool_number == 374): #374 == 906043
426 gcpy             self.writegc("(TOOL/MILL,␣9.53,␣0.00,␣3.17,␣0.00)")
427 gcpy             self.endmilltype = "keyhole"
428 gcpy             self.diameter = 9.525
429 gcpy             self.flute = 3.175
430 gcpy             self.radius = 6.35
431 gcpy             self.shaftdiameter = 6.35
432 gcpy             self.shaftheight = 3.175
433 gcpy             self.shaftlength = 20.0
434 gcpy             self.toolnumber = "906043"
435 gcpy         elif (tool_number == 375): #375 == 906053
436 gcpy             self.writegc("(TOOL/MILL,␣9.53,␣0.00,␣3.17,␣0.00)")
437 gcpy             self.endmilltype = "keyhole"
```

```

438 gcpy          self.diameter = 9.525
439 gcpy          self.flute = 3.175
440 gcpy          self.radius = 8
441 gcpy          self.shaftdiameter = 6.35
442 gcpy          self.shaftheight = 3.175
443 gcpy          self.shaftlength = 20.0
444 gcpy          self.toolnumber = "906053"
445 gcpy          elif (tool_number == 376): #376 == 907040
446 gcpy            self.writegc("(TOOL/MILL,␣12.7,␣0.00,␣4.77,␣0.00)")
447 gcpy            self.endmilltype = "keyhole"
448 gcpy            self.diameter = 12.7
449 gcpy            self.flute = 4.7625
450 gcpy            self.radius = 6.35
451 gcpy            self.shaftdiameter = 6.35
452 gcpy            self.shaftheight = 4.7625
453 gcpy            self.shaftlength = 20.0
454 gcpy            self.toolnumber = "907040"
455 gcpy          elif (tool_number == 378): #378 == 907050
456 gcpy            self.writegc("(TOOL/MILL,␣12.7,␣0.00,␣4.77,␣0.00)")
457 gcpy            self.endmilltype = "keyhole"
458 gcpy            self.diameter = 12.7
459 gcpy            self.flute = 4.7625
460 gcpy            self.radius = 8
461 gcpy            self.shaftdiameter = 6.35
462 gcpy            self.shaftheight = 4.7625
463 gcpy            self.shaftlength = 20.0
464 gcpy            self.toolnumber = "907050"
465 gcpy          #

```

3.3.1.6 Bowl This geometry is also useful for square endmills with a radius.

```

466 gcpy          elif (tool_number == 45981): #45981 == 445981
467 gcpy          #Amana Carbide Tipped Bowl & Tray 1/8 Radius x 1/2 Dia x 1/2 x 1/4
              Inch Shank
468 gcpy          self.writegc("(TOOL/MILL,0.03,␣0.00,␣10.00,␣30.00)")
469 gcpy          self.writegc("(TOOL/MILL,␣15.875,␣6.35,␣19.05,␣0.00)")
470 gcpy          self.endmilltype = "bowl"
471 gcpy          self.diameter = 12.7
472 gcpy          self.flute = 12.7
473 gcpy          self.radius = 3.175
474 gcpy          self.shaftdiameter = 6.35
475 gcpy          self.shaftheight = 12.7
476 gcpy          self.shaftlength = 20.0
477 gcpy          self.toolnumber = "445981"
478 gcpy          elif (tool_number == 45982): #0.507/2, 4.509
479 gcpy            self.writegc("(TOOL/MILL,␣15.875,␣6.35,␣19.05,␣0.00)")
480 gcpy            self.endmilltype = "bowl"
481 gcpy            self.diameter = 19.05
482 gcpy            self.flute = 15.875
483 gcpy            self.radius = 6.35
484 gcpy            self.shaftdiameter = 6.35
485 gcpy            self.shaftheight = 15.875
486 gcpy            self.shaftlength = 20.0
487 gcpy            self.toolnumber = "445982"
488 gcpy          #          elif (tool_number == 1370): #1370 == 401370
489 gcpy          #Whiteside Bowl & Tray Bit 1/4"SH, 1/8"R, 7/16"CD (5/16" cutting
              flute length)
490 gcpy          self.writegc("(TOOL/MILL,␣11.1125,␣8,␣3.175,␣0.00)")
491 gcpy          self.endmilltype = "bowl"
492 gcpy          self.diameter = 11.1125
493 gcpy          self.flute = 8
494 gcpy          self.radius = 3.175
495 gcpy          self.shaftdiameter = 6.35
496 gcpy          self.shaftheight = 8
497 gcpy          self.shaftlength = 20.0
498 gcpy          self.toolnumber = "401370"
499 gcpy          #          elif (tool_number == 1372): #1372/45982 == 401372
500 gcpy          #Whiteside Bowl & Tray Bit 1/4"SH, 1/4"R, 3/4"CD (5/8" cutting
              flute length)
501 gcpy          #Amana Carbide Tipped Bowl & Tray 1/4 Radius x 3/4 Dia x 5/8 x 1/4
              Inch Shank
502 gcpy          self.writegc("(TOOL/MILL,␣19.5,␣15.875,␣6.35,␣0.00)")
503 gcpy          self.endmilltype = "bowl"
504 gcpy          self.diameter = 19.5
505 gcpy          self.flute = 15.875
506 gcpy          self.radius = 6.35
507 gcpy          self.shaftdiameter = 6.35

```



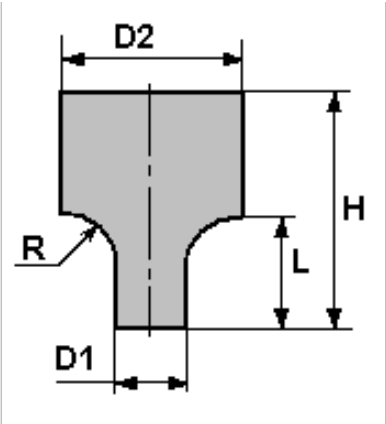
```
508 gcpy          self.shaftheight = 15.875
509 gcpy          self.shaftlength = 20.0
510 gcpy          self.toolnumber = "401372"
511 gcpy #
```

3.3.1.7 Tapered ball nose One vendor which provides such tooling is Precise Bits: <https://www.precisebits.com/products/carbidebits/taperedcarve250b2f.asp&filter=7>, but unfortunately, their tool numbering is ambiguous, the version of each major number (204 and 304) for their 1/4" shank tooling which is sufficiently popular to also be offered in a ZRN coating will be used. Similarly, the #501 and #502 PCB engravers from Carbide 3D are also supported.

```
512 gcpy          elif (tool_number == 501): #501 == 530131
513 gcpy          self.writegc("(TOOL/MILL,0.03,□0.00,□10.00,□30.00)")
514 gcpy #          self.currenttoolshape = self.toolshapes("tapered ball
                    ", 3.175, 5.561, 30, 0.254)
515 gcpy          self.endmilltype = "tapered□ball"
516 gcpy          self.diameter = 3.175
517 gcpy          self.flute = 5.561
518 gcpy          self.angle = 30
519 gcpy          self.tip = 0.254
520 gcpy          self.shaftdiameter = 3.175
521 gcpy          self.shaftheight = 5.561
522 gcpy          self.shaftlength = 10.0
523 gcpy          self.toolnumber = "530131"
524 gcpy          elif (tool_number == 502): #502 == 540131
525 gcpy          self.writegc("(TOOL/MILL,0.03,□0.00,□10.00,□20.00)")
526 gcpy #          self.currenttoolshape = self.toolshapes("tapered ball
                    ", 3.175, 4.117, 40, 0.254)
527 gcpy          self.endmilltype = "tapered□ball"
528 gcpy          self.diameter = 3.175
529 gcpy          self.flute = 4.117
530 gcpy          self.angle = 40
531 gcpy          self.tip = 0.254
532 gcpy          self.shaftdiameter = 3.175
533 gcpy          self.shaftheight = 4.117
534 gcpy          self.shaftlength = 10.0
535 gcpy          self.toolnumber = "540131"
536 gcpy #          elif (tool_number == 204):#
537 gcpy #              self.writegc("(")
538 gcpy #              self.currenttoolshape = self.tapered_ball(1.5875,
                    6.35, 38.1, 3.6)
539 gcpy #          elif (tool_number == 304):#
540 gcpy #              self.writegc("(")
541 gcpy #              self.currenttoolshape = self.tapered_ball(3.175, 6.35,
                    38.1, 2.4)
542 gcpy #
```

3.3.1.8 Roundover (corner rounding) Note that the parameters will need to incorporate the tip diameter into the overall diameter. CutViewer uses:

TOOL/CRMILL, Diameter1, Diameter2, Radius, Height, Length



```
543 gcpy          elif (tool_number == 56125):#0.508/2, 1.531 56125 == 603042
544 gcpy          self.writegc("(TOOL/CRMILL,□0.508,□6.35,□3.175,□7.9375,
                    □3.175)")
545 gcpy          self.endmilltype = "roundover"
546 gcpy          self.tip = 0.508
```

```

547 gcpy          self.diameter = 6.35 - self.tip
548 gcpy          self.flute = 8 - self.tip
549 gcpy          self.radius = 3.175 - self.tip
550 gcpy          self.shaftdiameter = 6.35
551 gcpy          self.shaftheight = 8
552 gcpy          self.shaftlength = 10.0
553 gcpy          self.toolnumber = "603042"
554 gcpy          elif (tool_number == 56142):#0.508/2, 2.921 56142 == 602032
555 gcpy          self.writegc("(TOOL/CRMILL,□0.508,□3.571875,□1.5875,□
                    5.55625,□1.5875)")
556 gcpy          self.endmilltype = "roundover"
557 gcpy          self.tip = 0.508
558 gcpy          self.diameter = 3.175 - self.tip
559 gcpy          self.flute = 4.7625 - self.tip
560 gcpy          self.radius = 1.5875 - self.tip
561 gcpy          self.shaftdiameter = 3.175
562 gcpy          self.shaftheight = 4.7625
563 gcpy          self.shaftlength = 10.0
564 gcpy          self.toolnumber = "602032"
565 gcpy #          elif (tool_number == 312):#1.524/2, 3.175
566 gcpy #          self.writegc("(TOOL/CRMILL, Diameter1, Diameter2,
                    Radius, Height, Length)")
567 gcpy #          elif (tool_number == 1568):#0.507/2, 4.509 1568 == 603032
568 gcpy ##FIX          self.writegc("(TOOL/CRMILL, 0.17018, 9.525,
                    4.7625, 12.7, 4.7625)")
569 gcpy ##          self.currenttoolshape = self.toolshapes("roundover",
                    3.175, 6.35, 3.175, 0.396875)
570 gcpy #          self.endmilltype = "roundover"
571 gcpy #          self.diameter = 3.175
572 gcpy #          self.flute = 6.35
573 gcpy #          self.radius = 3.175
574 gcpy #          self.tip = 0.396875
575 gcpy #          self.toolnumber = "603032"
576 gcpy ##https://www.amanatool.com/45982-carbide-tipped-bowl-tray-1-4-
                    radius-x-3-4-dia-x-5-8-x-1-4-inch-shank.html
577 gcpy #          elif (tool_number == 1570):#0.507/2, 4.509 1570 == 600002
                    ?!
578 gcpy #          self.writegc("(TOOL/CRMILL, 0.17018, 9.525, 4.7625,
                    12.7, 4.7625)")
579 gcpy ##          self.currenttoolshape = self.toolshapes("roundover",
                    4.7625, 9.525, 4.7625, 0.396875)
580 gcpy #          self.endmilltype = "roundover"
581 gcpy #          self.diameter = 4.7625
582 gcpy #          self.flute = 9.525
583 gcpy #          self.radius = 4.7625
584 gcpy #          self.tip = 0.396875
585 gcpy #          self.toolnumber = "600002"
586 gcpy #          elif (tool_number == 1572): #1572 = 604042
587 gcpy ##FIX          self.writegc("(TOOL/CRMILL, 0.17018, 9.525,
                    4.7625, 12.7, 4.7625)")
588 gcpy ##          self.currenttoolshape = self.toolshapes("roundover",
                    6.35, 12.7, 6.35, 0.396875)
589 gcpy #          self.endmilltype = "roundover"
590 gcpy #          self.diameter = 6.35
591 gcpy #          self.flute = 12.7
592 gcpy #          self.radius = 6.35
593 gcpy #          self.tip = 0.396875
594 gcpy #          self.toolnumber = "604042"
595 gcpy #          elif (tool_number == 1574): #1574 == 600062
596 gcpy ##FIX          self.writegc("(TOOL/CRMILL, 0.17018, 9.525,
                    4.7625, 12.7, 4.7625)")
597 gcpy ##          self.currenttoolshape = self.toolshapes("roundover",
                    9.525, 19.5, 9.515, 0.396875)
598 gcpy #          self.endmilltype = "roundover"
599 gcpy #          self.diameter = 9.525
600 gcpy #          self.flute = 19.5
601 gcpy #          self.radius = 9.515
602 gcpy #          self.tip = 0.396875
603 gcpy #          self.toolnumber = "600062"
604 gcpy #

```

3.3.1.9 Dovetails Unfortunately, tools which support undercuts such as dovetails are not supported by CutViewer (CAMotics will work for such tooling, at least dovetails which may be defined as "stub" endmills with a bottom diameter greater than upper diameter).

```

605 gcpy          elif (tool_number == 814): #814 == 814071

```

```
606 gcpy #Item 18J1607, 1/2" 14ř Dovetail Bit, 8mm shank
607 gcpy          self.writegc("(T00L/MILL,␣12.7,␣6.367,␣12.7,␣0.00)")
608 gcpy          #      dt_bottomdiameter, dt_topdiameter, dt_height, dt_angle
609 gcpy          #      https://www.leevalley.com/en-us/shop/tools/power-tool-
610 gcpy #          self.currenttoolshape = self.toolshapes("dovetail",
12.7, 12.7, 14)
611 gcpy          self.endmilltype = "dovetail"
612 gcpy          self.diameter = 12.7
613 gcpy          self.flute = 12.7
614 gcpy          self.angle = 14
615 gcpy          self.toolnumber = "814071"
616 gcpy          elif (tool_number == 808079): #45828 == 808071
617 gcpy          self.writegc("(T00L/MILL,␣12.7,␣6.816,␣20.95,␣0.00)")
618 gcpy          #      http://www.amanatool.com/45828-carbide-tipped-dovetail
619 gcpy #          self.currenttoolshape = self.toolshapes("dovetail",
12.7, 20.955, 8)
620 gcpy          self.endmilltype = "dovetail"
621 gcpy          self.diameter = 12.7
622 gcpy          self.flute = 20.955
623 gcpy          self.angle = 8
624 gcpy          self.toolnumber = "808071"
625 gcpy #
```

Each tool must be modeled in 3D using OpenSCAD commands, but it will also be necessary to have a consistent structure for managing the various shapes and aspects of shapes.

While tool shapes were initially handled as geometric shapes stored in Python variables, processing them as such after the fashion of OpenSCAD required the use of `union()` commands and assigning a small initial object (usually a primitive placed at the origin) so that the union could take place. This has the result of creating a nested union structure in the CSG tree which can quickly become so deeply nested that it exceeds the limits set in PythonSCAD.

As was discussed in the PythonSCAD Google Group (<https://groups.google.com/g/pythonscad/c/rtiYa38W8tY>), if a list is used instead, then the contents of the list are added all at once at a single level when processed.

An example file which shows this concept:

```
from openscad import *
fn=200

box = cube([40,40,40])

features = []

features.append(cube([36,36,40]) + [2,2,2])
features.append(cylinder(d=20,h=5) + [20,20,-1])
features.append(cylinder(d=3,h=10) ^ [[5,35],[5,35], -1])

part = difference(box, features)

show(part)
```

As per usual, the OpenSCAD command is simply a dispatcher:

```
48 gpcpscad module toolchange(tool_number, speed){
49 gpcpscad     gcp.toolchange(tool_number, speed);
50 gpcpscad }
```

For example:

```
toolchange(small_square_tool_num, speed);
```

(the assumption is that all speed rates in a file will be the same, so as to account for the most frequent use case of a trim router with speed controlled by a dial setting and feed rates/ratios being calculated to provide the correct chipload at that setting.)

3.3.1.10 closing G-code With the tools delineated, the module is closed out and the toolchange information written into the G-code as well as the command to start the spindle at the specified speed.

```
626 gcpy          self.writegc("M6T", str(tool_number))
627 gcpy          self.writegc("M03S", str(speed))
```

3.3.2 Laser support

Two possible options for supporting a laser present themselves: color-coded DXFs or direct G-code support. An example file for the latter:

<https://lasergcode.com/test-file-and-samples/depth-of-focus-test/>

```
M3 S0
S0
G0X0Y16
S1000
G1X100F1200
S0
M5 S0
M3 S0
S0
G0X0Y12
S1000
G1X100F1000
S0
M5 S0
M3 S0
S0
G0X0Y8
S1000
G1X100F800
S0
M5 S0
M3 S0
S0
G0X0Y4
S1000
G1X100F600
S0
M5 S0
M3 S0
S0
G0X0Y0
S1000
G1X100F400
S0
M5 S0
```

3.4 Shapes and tool movement

With all the scaffolding in place, it is possible to model the tool and `hull()` between copies of the `cut...` 3D model of the tool, or a cross-section of it for both `cut...` and `rapid...` operations.

The majority of commands will be more general, focusing on tooling which is generally supported by this library, moving in lines and arcs so as to describe shapes which lend themselves to representation with those tools and which match up with both toolpaths and supported geometry in Carbide Create, and the usage requirements of the typical user.

This structure has the notable advantage that if a tool shape is represented as a list and always handled thus, then representing complex shapes which need to be represented in discrete elements/parts becomes a natural thing to do and the program architecture is simpler since all possible shapes may be handled by the same code/logic with no need to identify different shapes and handle them differently.

Note that it will be preferable to use `extend` if the variable to be added contains a list rather than `append` since the former will flatten out the list and add the individual elements, so that a list remains a list of elements rather than becoming a list of lists and elements, except that there will be at least two elements to each tool model list:

- cutting *tool* shape (note that this may be either a single model, or a list of discrete slices of the tool shape)
- *shaft*

and when a cut is made by hulling each element from the cut begin position to its end position, this will be done using different colors so that the shaft rubbing may be identified on the 3D surface of the preview of the cut.

3.4.0.1 Tooling for Undercutting Toolpaths There are several notable candidates for undercutting tooling.

- Keyhole tools — intended to cut slots for retaining hardware used for picture hanging, they may be used to create slots for other purposes Note that it will be necessary to model these thrice, once for the actual keyhole cutting, second for the fluted portion of the shaft, and then the shaft should be modeled for collision <https://assetssc.leevalley.com/en-gb/shop/tools/power-tool-accessories/router-bits/30113-keyhole-router-bits>

- Dovetail cutters — used for the joinery of the same name, they cut a large area at the bottom which slants up to a narrower region at a defined angle
- Lollipop cutters — normally used for 3D work, as their name suggests they are essentially a (cutting) ball on a narrow stick (the tool shaft), they are mentioned here only for completeness' sake and are not (at this time) implemented
- Threadmill — used for cutting threads, normally a single form geometry is used on a CNC.

3.4.1 Generalized commands and cuts

The first consideration is a naming convention which will allow a generalized set of associated commands to be defined. The initial version will only create OpenSCAD commands for 3D modeling and write out matching DXF files. At a later time this will be extended with G-code support. There are three different movements in G-code which will need to be handled. Rapid commands will be used for G0 movements and will not appear in DXFs but will appear in G-code files, while straight line cut (G1) and arc (G2/G3) commands may appear in both G-code and DXF files, depending on the specific command invoked.

3.4.2 Movement and color

toolmovement
shaftmovement

The first command which must be defined is `toolmovement` which is used as the core of the other commands, affording a 3D model of the tool moving in a straight line. A matching `shaftmovement` command will allow modeling collision of the shaft with the stock should it occur. This differentiation raises the matter of color representation. Using a different color for the shape of the endmill when cutting and for rapid movements will similarly allow identifying instances of the tool crashing through stock at rapid speed.

```
629 gcpy      def setcolor(self,
630 gcpy                               cutcolor = "green",
631 gcpy                               rapidcolor = "orange",
632 gcpy                               shaftcolor = "red"):
633 gcpy      self.cutcolor = cutcolor
634 gcpy      self.rapidcolor = rapidcolor
635 gcpy      self.shaftcolor = shaftcolor
```

The possible colors are those of Web colors (https://en.wikipedia.org/wiki/Web_colors), while DXF has its own set of colors based on numbers (see table) and applying a Venn diagram and removing problematic extremes we arrive at the third column above as black and white are potentially inconsistent/confusing since at least one CAD program toggles them based on light/dark mode being applied to its interface.

Table 1: Colors in OpenSCAD and DXF		
Web Colors (OpenSCAD)	DXF	Both
Black	"Black" (0)	
Red	"Red" (1)	Red
Yellow	"Yellow" (2)	Yellow
Green	"Green" (3)	Green
	"Cyan" (4)	
Blue	"Blue" (5)	Blue
	"Magenta" (6)	
White	"White" (7)	
Gray	"Dark Gray" (8)	(Dark) Gray
	"Light Gray" (9)	
Silver		
Maroon		
Olive		
Lime		
Aqua		
Teal		
Navy		
Fuchsia		
Purple		

(note that the names are not case-sensitive)

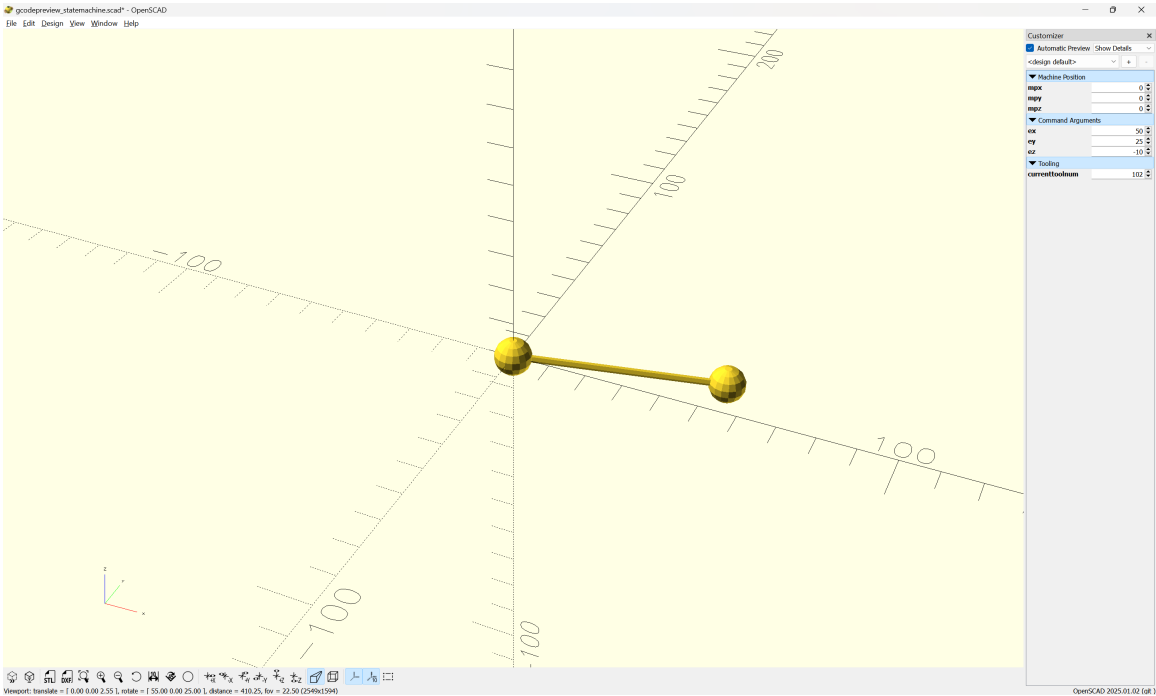
Most tools are easily implemented with concise 3D descriptions which may be connected with a simple `hull` operation. Note that extending the normal case to a pair of such operations, one for the shaft, the other for the cutting shape will markedly simplify the code, and will make it possible to color-code the shaft which may afford indication of instances of it rubbing against the stock.

Note that the variables `self.rapids` and `self.toolpaths` are used to hold the list of accumulated 3D models of the rapid motions and cuts as elements in lists so that they may be differenced from the stock.

3.4.2.1 **toolmovement** The `toolmovement` command incorporates the color variables to indicate cutting and differentiate rapid movements and the tool shaft.

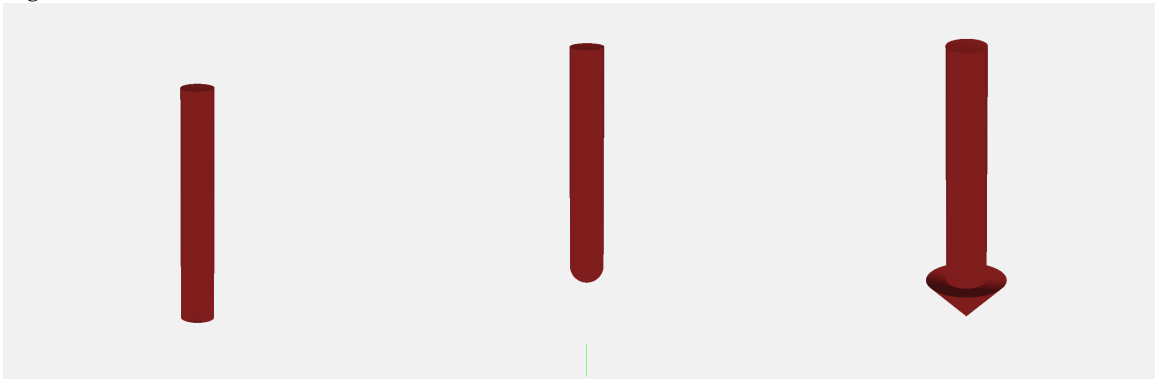
Diagramming this is quite straight-forward — there is simply a movement made from the current position to the end. If we start at the origin, `X0, Y0, Z0`, then it is simply a straight-line movement (rapid)/cut (possibly a partial cut in the instance of a keyhole or roundover tool), and no variables change value.

The code for diagramming this is quite straight-forward. A BlockSCAD implementation is available at: <https://www.blockscad3d.com/community/projects/1894400>, and the OpenSCAD version is only a little more complex (adding code to ensure positioning):



```
637 gcpy      def toolmovement(self, bx, by, bz, ex, ey, ez, step = 0):
638 gcpy          tlist = []
639 gcpy          if step > 0:
640 gcpy              steps = step
641 gcpy          else:
642 gcpy              steps = self.steps
```

3.4.2.2 **Normal Tooling/toolshapes** Most tooling has quite standard shapes and are defined by their profile as defined in a class which simply defines/declares their shape and `hull()`s them together:



- Square (#201 and 102) — able to cut a flat bottom, perpendicular side and right angle, their simple and easily understood geometry makes them a standard choice
- Ballnose (#202 and 101) — rounded, they are the standard choice for concave and organic shapes
- V tooling (#301, 302 and 390) — pointed at the tip, they are available in a variety of angles and diameters and may be used for decorative V carving, or for chamfering or cutting specific angles

Note that the module for creating movement of the tool will need to handle all of the different tool shapes, generating a list of `hull()` commands which describe the 3D region which tool

movement describes.

endmill square 3.4.2.3 Square (including O-flute) The endmill square is a simple cylinder:

```
644 gcpy         if self.endmilltype == "square":
645 gcpy             ts = cylinder(r1=(self.diameter / 2), r2=(self.diameter
                        / 2), h=self.flute, center = False)
646 gcpy             tslist.append(hull(ts.translate([bx, by, bz]), ts.
                        translate([ex, ey, ez])))
647 gcpy             return tslist
648 gcpy
649 gcpy         if self.endmilltype == "O-flute":
650 gcpy             ts = cylinder(r1=(self.diameter / 2), r2=(self.diameter
                        / 2), h=self.flute, center = False)
651 gcpy             tslist.append(hull(ts.translate([bx, by, bz]), ts.
                        translate([ex, ey, ez])))
652 gcpy             return tslist
```

ballnose 3.4.2.4 Ball nose (including tapered ball nose) The ballnose is modeled as a hemisphere joined with a cylinder:

```
654 gcpy         if self.endmilltype == "ball":
655 gcpy             b = sphere(r=(self.diameter / 2))
656 gcpy             s = cylinder(r1=(self.diameter / 2), r2=(self.diameter
                        / 2), h=self.flute, center=False)
657 gcpy             bs = union(b, s)
658 gcpy             bs = bs.translate([0, 0, (self.diameter / 2)])
659 gcpy             tslist.append(hull(bs.translate([bx, by, bz]), bs.
                        translate([ex, ey, ez])))
660 gcpy             return tslist
661 gcpy #
```

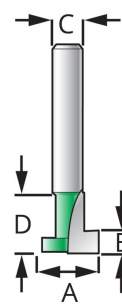
3.4.2.5 bowl The bowl tool is modeled as a series of cylinders stacked on top of each other and hull()ed together:

```
662 gcpy         if self.endmilltype == "bowl":
663 gcpy             inner = cylinder(r1 = self.diameter/2 - self.radius, r2
                        = self.diameter/2 - self.radius, h = self.flute)
664 gcpy             outer = cylinder(r1 = self.diameter/2, r2 = self.
                        diameter/2, h = self.flute - self.radius)
665 gcpy             outer = outer.translate([0,0, self.radius])
666 gcpy             slices = hull(outer, inner)
667 gcpy #         slices = cylinder(r1 = 0.0001, r2 = 0.0001, h = 0.0001, center
                        =False)
668 gcpy             for i in range(1, 90 - self.steps, self.steps):
669 gcpy                 slice = cylinder(r1 = self.diameter / 2 - self.
                        radius + self.radius * Sin(i), r2 = self.
                        diameter / 2 - self.radius + self.radius * Sin(i
                        +self.steps), h = self.radius/90, center=False)
670 gcpy                 slices = hull(slices, slice.translate([0, 0, self.
                        radius - self.radius * Cos(i+self.steps)]))
671 gcpy             tslist.append(hull(slices.translate([bx, by, bz]),
                        slices.translate([ex, ey, ez])))
672 gcpy             return tslist
673 gcpy #
```

endmill v 3.4.2.6 V The endmill v is modeled as a cylinder with a zero width base and a second cylinder for the shaft (note that Python’s math defaults to radians, hence the need to convert from degrees):

```
674 gcpy         if self.endmilltype == "V":
675 gcpy             v = cylinder(r1=0, r2=(self.diameter / 2), h=((self.
                        diameter / 2) / Tan((self.angle / 2))), center=False
                        )
676 gcpy #             s = cylinder(r1=(self.diameter / 2), r2=(self.
                        diameter / 2), h=self.flute, center=False)
677 gcpy #             sh = s.translate([0, 0, ((self.diameter / 2) / Tan
                        ((self.angle / 2)))]))
678 gcpy             tslist.append(hull(v.translate([bx, by, bz]), v.
                        translate([ex, ey, ez])))
679 gcpy             return tslist
```

3.4.2.7 Keyhole Keyhole toolpaths (see: subsection 3.7.0.2.3 are intended for use with tooling which projects beyond the narrower shaft and so will cut usefully underneath the visible surface. Also described as “undercut” tooling, but see below.



Keyhole Router Bits

#	A	B	C	D
374	3/8"	1/8"	1/4"	3/8"
375	9.525mm	3.175mm	8mm	9.525mm
376	1/2"	3/16"	1/4"	1/2"
378	12.7mm	4.7625mm	8mm	12.7mm



```
681 gcpy      if self.endmilltype == "keyhole":
682 gcpy          kh = cylinder(r1=(self.diameter / 2), r2=(self.diameter
                        / 2), h=self.flute, center=False)
683 gcpy          sh = (cylinder(r1=(self.radius / 2), r2=(self.radius /
                        2), h=self.flute*2, center=False))
684 gcpy          tslist.append(hull(kh.translate([bx, by, bz]), kh.
                        translate([ex, ey, ez])))
685 gcpy          tslist.append(hull(sh.translate([bx, by, bz]), sh.
                        translate([ex, ey, ez])))
686 gcpy      return tslist
```

3.4.2.8 Tapered ball nose The tapered ball nose tool is modeled as a sphere at the tip and a pair of cylinders, where one (a cone) describes the taper, while the other represents the shaft.

```
688 gcpy      if self.endmilltype == "tapered_ball":
689 gcpy          b = sphere(r=(self.tip / 2))
690 gcpy          s = cylinder(r1=(self.tip / 2), r2=(self.diameter / 2),
                        h=self.flute, center=False)
691 gcpy          bshape = union(b, s)
692 gcpy          tslist.append(hull(bshape.translate([bx, by, bz]),
                        bshape.translate([ex, ey, ez])))
693 gcpy      return tslist
```

dovetail **3.4.2.9 Dovetails** The dovetail is modeled as a cylinder with the differing bottom and top diameters determining the angle (though dt_angle is still required as a parameter)

```
695 gcpy      if self.endmilltype == "dovetail":
696 gcpy          dt = cylinder(r1=(self.diameter / 2), r2=(self.diameter
                        / 2) - self.flute * Tan(self.angle), h= self.flute,
                        center=False)
697 gcpy          tslist.append(hull(dt.translate([bx, by, bz]), dt.
                        translate([ex, ey, ez])))
698 gcpy          return tslist
699 gcpy      if self.endmilltype == "other":
700 gcpy          tslist = []
701 gcpy #      def dovetail(self, dt_bottomdiameter, dt_topdiameter,
                        dt_height, dt_angle):
702 gcpy #          return cylinder(r1=(dt_bottomdiameter / 2), r2=(
                        dt_topdiameter / 2), h= dt_height, center=False)
```

3.4.2.10 Concave toolshapes While normal tooling may be represented with a one (or more) hull operation(s) betwixt two 3D toolshapes (or six in the instance of keyhole tools), concave tooling such as roundover/radius tooling require multiple sections or even slices of the tool shape to be modeled separately which are then hulled together. Something of this can be seen in the manual work-around for previewing them: <https://community.carbide3d.com/t/using-unsupported-tooling-in-carbide-create-roundover-cove-radius-bits/43723>.

Because it is necessary to divide the tooling into vertical slices and call the hull operation for each slice the tool definitions have to be called separately in the `cut...` modules, or integrated at the lowest level.

3.4.2.11 Roundover tooling It is not possible to represent all tools using tool changes as coded above which require using a hull operation between 3D representations of the tools at the beginning and end points. Tooling which cannot be so represented will be implemented separately below, see paragraph 3.4.2.10 — roundover tooling will need to generate a list of slices of the tool shape hulled together.

```
704 gcpy         if self.endmilltype == "roundover":
705 gcpy             shaft = cylinder(self.steps, self.tip/2, self.tip/2)
706 gcpy             toolpath = hull(shaft.translate([bx, by, bz]), shaft.
                                translate([ex, ey, ez]))
707 gcpy             shaft = cylinder(self.flute, self.diameter/2 + self.tip
                                /2, self.diameter/2 + self.tip/2)
708 gcpy             toolpath = toolpath.union(hull(shaft.translate([bx, by,
                                bz + self.radius]), shaft.translate([ex, ey, ez +
                                self.radius])))
709 gcpy             tslist = [toolpath]
710 gcpy             slice = cylinder(0.0001, 0.0001, 0.0001)
711 gcpy             slices = slice
712 gcpy             for i in range(1, 90 - self.steps, self.steps):
713 gcpy                 dx = self.radius*cos(i)
714 gcpy                 dxx = self.radius*cos(i + self.steps)
715 gcpy                 dzz = self.radius*sin(i)
716 gcpy                 dz = self.radius*sin(i + self.steps)
717 gcpy                 dh = dz - dzz
718 gcpy                 slice = cylinder(r1 = self.tip/2+self.radius-dx, r2
                                = self.tip/2+self.radius-dxx, h = dh)
719 gcpy                 slices = slices.union(hull(slice.translate([bx, by,
                                bz+dz]), slice.translate([ex, ey, ez+dz])))
720 gcpy             tslist.append(slices)
721 gcpy             return tslist
722 gcpy #
```

Note that this routine does *not* alter the machine position variables since it may be called multiple times for a given toolpath, *e.g.*, for arcs. This command will then be called in the definitions for rapid and cutline which only differ in which variable the 3D model list is unioned with.

shaftmovement A similar routine will be used to handle the shaftmovement.

3.4.2.12 shaftmovement The shaftmovement command uses variables defined as part of the tool definition to determine the Z-axis position of the cylinder used to represent the shaft and its diameter and height:

```
723 gcpy         def shaftmovement(self, bx, by, bz, ex, ey, ez):
724 gcpy             tslist = []
725 gcpy             ts = cylinder(r1=(self.shaftdiameter / 2), r2=(self.
                                shaftdiameter / 2), h=self.shaftlength, center = False)
726 gcpy             ts = ts.translate([0, 0, self.shaftheight])
727 gcpy             tslist.append(hull(ts.translate([bx, by, bz]), ts.translate
                                ([ex, ey, ez])))
728 gcpy             return tslist
```

3.4.2.13 rapid and cut (lines) A matching pair of commands is made for these, and rapid is used as the basis for a series of commands which match typical usages of G0.

Note the addition of a Laser mode which simulates the tool having been turned off — likely further changes will be required.

```
730 gcpy         def rapid(self, ex, ey, ez, laser = 0):
731 gcpy #             print(self.rapidcolor)
732 gcpy             if laser == 0:
733 gcpy                 tm = self.toolmovement(self.xpos(), self.ypos(), self.
                                zpos(), ex, ey, ez)
734 gcpy                 tm = color(tm, self.shaftcolor)
735 gcpy                 ts = self.shaftmovement(self.xpos(), self.ypos(), self.
                                zpos(), ex, ey, ez)
736 gcpy                 ts = color(ts, self.rapidcolor)
737 gcpy                 self.toolpaths.extend([tm, ts])
738 gcpy                 self.setxpos(ex)
739 gcpy                 self.setypos(ey)
740 gcpy                 self.setzpos(ez)
741 gcpy
742 gcpy         def cutline(self, ex, ey, ez):
```

```

743 gcpy #         print(self.cutcolor)
744 gcpy #         print(ex, ey, ez)
745 gcpy         tm = self.toolmovement(self.xpos(), self.ypos(), self.zpos
              (), ex, ey, ez)
746 gcpy         tm = color(tm, self.cutcolor)
747 gcpy         ts = self.shaftmovement(self.xpos(), self.ypos(), self.zpos
              (), ex, ey, ez)
748 gcpy         ts = color(ts, self.rapidcolor)
749 gcpy         self.setxpos(ex)
750 gcpy         self.setypos(ey)
751 gcpy         self.setzpos(ez)
752 gcpy         self.toolpaths.extend([tm, ts])

```

It is then possible to add specific rapid... commands to match typical usages of G-code. The first command needs to be a move to/from the safe Z height. In G-code this would be:

```

(Move to safe Z to avoid workholding)
G53G0Z-5.000

```

but in the 3D model, since we do not know how tall the Z-axis is, we simply move to safe height and use that as a starting point:

```

754 gcpy     def movetosafeZ(self):
755 gcpy         rapid = self.rapid(self.xpos(), self.ypos(), self.
              retractheight)
756 gcpy #         if self.generatepaths == True:
757 gcpy #             rapid = self.rapid(self.xpos(), self.ypos(), self.
              retractheight)
758 gcpy #             self.rapids = self.rapids.union(rapid)
759 gcpy #         else:
760 gcpy #         if (generategcode == true) {
761 gcpy #             writecomment("PREPOSITION FOR RAPID PLUNGE");Z25.650
762 gcpy #             //G1Z24.663F381.0, "F", str(plunge)
763 gcpy #             if self.generatepaths == False:
764 gcpy #                 return rapid
765 gcpy #             else:
766 gcpy #                 return cube([0.001, 0.001, 0.001])
767 gcpy         return rapid
768 gcpy
769 gcpy     def rapidXYZ(self, ex, ey, ez):
770 gcpy         rapid = self.rapid(ex, ey, ez)
771 gcpy #         if self.generatepaths == False:
772 gcpy         return rapid
773 gcpy
774 gcpy     def rapidXY(self, ex, ey):
775 gcpy         rapid = self.rapid(ex, ey, self.zpos())
776 gcpy #         if self.generatepaths == True:
777 gcpy #             self.rapids = self.rapids.union(rapid)
778 gcpy #         else:
779 gcpy #         if self.generatepaths == False:
780 gcpy         return rapid
781 gcpy
782 gcpy     def rapidXZ(self, ex, ez):
783 gcpy         rapid = self.rapid(ex, self.ypos(), ez)
784 gcpy #         if self.generatepaths == False:
785 gcpy         return rapid
786 gcpy
787 gcpy     def rapidYZ(self, ey, ez):
788 gcpy         rapid = self.rapid(self.xpos(), ey, ez)
789 gcpy #         if self.generatepaths == False:
790 gcpy         return rapid
791 gcpy
792 gcpy     def rapidX(self, ex):
793 gcpy         rapid = self.rapid(ex, self.ypos(), self.zpos())
794 gcpy #         if self.generatepaths == False:
795 gcpy         return rapid
796 gcpy
797 gcpy     def rapidY(self, ey):
798 gcpy         rapid = self.rapid(self.xpos(), ey, self.zpos())
799 gcpy #         if self.generatepaths == False:
800 gcpy         return rapid
801 gcpy
802 gcpy     def rapidZ(self, ez):
803 gcpy         rapid = [self.rapid(self.xpos(), self.ypos(), ez)]
804 gcpy #         if self.generatepaths == True:
805 gcpy #             self.rapids = self.rapids.union(rapid)
806 gcpy #         else:
807 gcpy #         if self.generatepaths == False:

```

```
808 gcpy          return rapid
```

Note that rather than re-create the matching OpenSCAD commands as descriptors, due to the issue of redirection and return values and the possibility for errors it is more expedient to simply re-create the matching command (at least for the rapids):

```
52 gcpscad module movetosafeZ(){
53 gcpscad     gcp.rapid(gcp.xpos(), gcp.ypos(), retractheight);
54 gcpscad }
55 gcpscad
56 gcpscad module rapid(ex, ey, ez) {
57 gcpscad     gcp.rapid(ex, ey, ez);
58 gcpscad }
59 gcpscad
60 gcpscad module rapidXY(ex, ey) {
61 gcpscad     gcp.rapid(ex, ey, gcp.zpos());
62 gcpscad }
63 gcpscad
64 gcpscad module rapidXZ(ex, ez) {
65 gcpscad     gcp.rapid(ex, gcp.zpos(), ez);
66 gcpscad }
67 gcpscad
68 gcpscad module rapidZ(ez) {
69 gcpscad     gcp.rapid(gcp.xpos(), gcp.ypos(), ez);
70 gcpscad }
```

cut... Similarly, there is a series of cutline... commands as predicted above.
cutline The Python commands cut... add the currenttool to the toolpath hulled together at the current position and the end position of the move. For cutline, this is a straight-forward connection of the current (beginning) and ending coordinates:

```
810 gcpy      def cutlinedxf(self, ex, ey, ez):
811 gcpy          self.dxfline(self.currenttoolnumber(), self.xpos(), self.
                    ypos(), ex, ey)
812 gcpy          self.cutline(ex, ey, ez)
813 gcpy
814 gcpy      def cutlinedxfgc(self, ex, ey, ez):
815 gcpy          self.dxfline(self.currenttoolnumber(), self.xpos(), self.
                    ypos(), ex, ey)
816 gcpy          self.writegc("G01_X", str(ex), "_Y", str(ey), "_Z", str(ez)
                    )
817 gcpy          self.cutline(ex, ey, ez)
818 gcpy
819 gcpy      def cutvertexdx(self, ex, ey, ez):
820 gcpy          self.addvertex(self.currenttoolnumber(), ex, ey)
821 gcpy          self.writegc("G01_X", str(ex), "_Y", str(ey), "_Z", str(ez)
                    )
822 gcpy          self.cutline(ex, ey, ez)
823 gcpy
824 gcpy      def cutlineXYZwithfeed(self, ex, ey, ez, feed):
825 gcpy          return self.cutline(ex, ey, ez)
826 gcpy
827 gcpy      def cutlineXYZ(self, ex, ey, ez):
828 gcpy          return self.cutline(ex, ey, ez)
829 gcpy
830 gcpy      def cutlineXYwithfeed(self, ex, ey, feed):
831 gcpy          return self.cutline(ex, ey, self.zpos())
832 gcpy
833 gcpy      def cutlineXY(self, ex, ey):
834 gcpy          return self.cutline(ex, ey, self.zpos())
835 gcpy
836 gcpy      def cutlineXZwithfeed(self, ex, ez, feed):
837 gcpy          return self.cutline(ex, self.ypos(), ez)
838 gcpy
839 gcpy      def cutlineXZ(self, ex, ez):
840 gcpy          return self.cutline(ex, self.ypos(), ez)
841 gcpy
842 gcpy      def cutlineXwithfeed(self, ex, feed):
843 gcpy          return self.cutline(ex, self.ypos(), self.zpos())
844 gcpy
845 gcpy      def cutlineX(self, ex):
846 gcpy          return self.cutline(ex, self.ypos(), self.zpos())
847 gcpy
848 gcpy      def cutlineYZ(self, ey, ez):
849 gcpy          return self.cutline(self.xpos(), ey, ez)
850 gcpy
851 gcpy      def cutlineYwithfeed(self, ey, feed):
```

```
852 gcpy          return self.cutline(self.xpos(), ey, self.zpos())
853 gcpy
854 gcpy          def cutlineY(self, ey):
855 gcpy              return self.cutline(self.xpos(), ey, self.zpos())
856 gcpy
857 gcpy          def cutlineZgcfeed(self, ez, feed):
858 gcpy              self.writegc("G01_Z", str(ez), "F", str(feed))
859 gcpy              return self.cutline(self.xpos(), self.ypos(), ez)
860 gcpy
861 gcpy          def cutlineZwithfeed(self, ez, feed):
862 gcpy              return self.cutline(self.xpos(), self.ypos(), ez)
863 gcpy
864 gcpy          def cutlineZ(self, ez):
865 gcpy              return self.cutline(self.xpos(), self.ypos(), ez)
```

The matching OpenSCAD command is a descriptor:

```
72 gcpscad module cutline(ex, ey, ez){
73 gcpscad     gcp.cutline(ex, ey, ez);
74 gcpscad }
75 gcpscad
76 gcpscad module cutlinedxfgc(ex, ey, ez){
77 gcpscad     gcp.cutlinedxfgc(ex, ey, ez);
78 gcpscad }
79 gcpscad
80 gcpscad module cutlineZgcfeed(ez, feed){
81 gcpscad     gcp.cutlineZgcfeed(ez, feed);
82 gcpscad }
```

3.4.2.14 Arcs A further consideration here is that G-code and DXF support arcs in addition to the lines already implemented. Implementing arcs wants at least the following options for quadrant and direction:

- cutarcCW — cut a partial arc described in a clock-wise direction
- cutarcCC — counter-clock-wise
- cutarcNWCW — cut the upper-left quadrant of a circle moving clockwise
- cutarcNWCC — upper-left quadrant counter-clockwise
- cutarcNECW
- cutarcNECC
- cutarcSECW
- cutarcSECC
- cutarcNECW
- cutarcNECC
- cutcircleCC — while it won't matter for generating a DXF, when G-code is implemented direction of cut will be a consideration for that
- cutcircleCW
- cutcircleCCdxf
- cutcircleCWdxf

It will be necessary to have two separate representations of arcs — the G-code and DXF may be easily and directly supported with a single command, but representing the matching tool movement in OpenSCAD will require a series of short line movements which approximate the arc cutting in each direction and at changing Z-heights so as to allow for threading and similar operations. Note that there are the following representations/interfaces for representing an arc:

- G-code — G2 (clockwise) and G3 (counter-clockwise) arcs may be specified, and since the endpoint is the positional requirement, it is most likely best to use the offset to the center (I and J), rather than the radius parameter (K) G2/3 ...
- DXF — dxfarc(xcenter, ycenter, radius, anglebegin, endangle, tn)
- approximation of arc using lines (OpenSCAD) in both clock-wise and counter-clock-wise directions

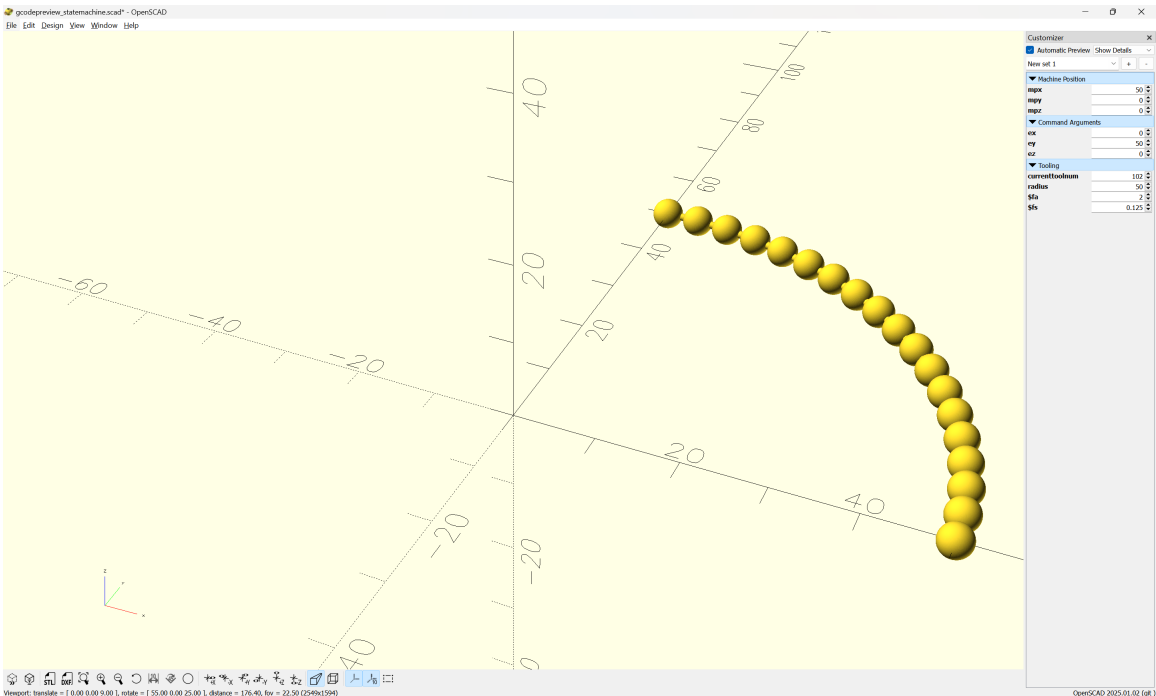
Cutting the quadrant arcs greatly simplifies the calculation and interface for the modules. A full set of 8 will be necessary, then circles will have a pair of modules (one for each cut direction) made for them.

Parameters which will need to be passed in are:

- `ex` — note that the matching origins (`bx`, `by`, `bz`) as well as the (current) toolnumber are accessed using the appropriate commands for machine position
- `ey`
- `ez` — allowing a different Z position will make possible threading and similar helical tool-paths
- `xcenter` — the center position will be specified as an absolute position which will require calculating the offset when it is used for G-code's IJ, for which `xctr/yctr` are suggested
- `ycenter`
- `radius` — while this could be calculated, passing it in as a parameter is both convenient and (potentially) could be used as a check on the other parameters
- `tpzreldim` — the relative depth (or increase in height) of the current cutting motion

Since OpenSCAD does not have an arc movement command it is necessary to iterate through a `cutarcCW` loop: `cutarcCW` (clockwise) or `cutarcCC` (counterclockwise) to handle the drawing and processing of the `cutline()` toolpaths as short line segments which additionally affords a single point of control for adding additional features such as allowing the depth to vary as one cuts along an arc (the line version is used rather than shape so as to capture the changing machine positions with each step through the loop). Note that the definition matches the DXF definition of defining the center position with a matching radius, but it will be necessary to move the tool to the actual origin, and to calculate the end position when writing out a G2/G3 arc.

This brings to the fore the fact that at its heart, this program is simply graphing math in 3D using tools (as presaged by the book series *Make:Geometry/Trigonometry/Calculus*). This is clear in a depiction of the algorithm for the `cutarcCC/CW` commands, where the `x` value is the cos of the radius and the `y` value the sin:



The code for which makes this obvious:

```
/* [Machine Position] */
mpx = 0;
/* [Machine Position] */
mpy = 0;
/* [Machine Position] */
mpz = 0;

/* [Command Arguments] */
ex = 50;
/* [Command Arguments] */
ey = 25;
/* [Command Arguments] */
ez = -10;

/* [Tooling] */
```

```

currenttoolnum = 102;

machine_extents();

radius = 50;
$fa = 2;
$fs = 0.125;

plot_arc(radius, 0, 0, 0, radius, 0, 0, 0, radius, 0, 90, 5);

module plot_arc(bx, by, bz, ex, ey, ez, acx, acy, radius, barc, earc, inc){
for (i = [barc : inc : earc-inc]) {
  union(){
    hull()
    {
      translate([acx + cos(i)*radius,
                 acy + sin(i)*radius,
                 0]){
        sphere(r=0.5);
      }
      translate([acx + cos(i+inc)*radius,
                 acy + sin(i+inc)*radius,
                 0]){
        sphere(r=0.5);
      }
    }
    translate([acx + cos(i)*radius,
               acy + sin(i)*radius,
               0]){
      sphere(r=2);
    }
    translate([acx + cos(i+inc)*radius,
               acy + sin(i+inc)*radius,
               0]){
      sphere(r=2);
    }
  }
}
}

module machine_extents(){
translate([-200, -200, 20]){
  cube([0.001, 0.001, 0.001], center=true);
}
translate([200, 200, 20]){
  cube([0.001, 0.001, 0.001], center=true);
}
}

```

Note that it is necessary to move to the beginning cutting position before calling, and that it is necessary to pass in the relative change in Z position/depth. (Previous iterations calculated the increment of change outside the loop, but it is more workable to do so inside.)

```

867 gcpy      def cutarcCC(self, barc, earc, xcenter, ycenter, radius,
868 gcpy          tpzreldim, stepsizearc=1):
869 gcpy          tpzinc = tpzreldim / (earc - barc)
870 gcpy          i = barc
871 gcpy          while i < earc:
872 gcpy              self.cutline(xcenter + radius * Cos(math.radians(i)),
873 gcpy                  ycenter + radius * Sin(math.radians(i)), self.zpos()
874 gcpy                  +tpzinc)
875 gcpy              i += stepsizearc
876 gcpy          self.setxpos(xcenter + radius * Cos(math.radians(earc)))
877 gcpy          self.setypos(ycenter + radius * Sin(math.radians(earc)))
878 gcpy
879 gcpy      def cutarcCW(self, barc, earc, xcenter, ycenter, radius,
880 gcpy          tpzreldim, stepsizearc=1):
881 gcpy          print(str(self.zpos()))
882 gcpy          print(str(ez))
883 gcpy          print(str(barc - earc))
884 gcpy          tpzinc = ez - self.zpos() / (barc - earc)
885 gcpy          print(str(tpzinc))
886 gcpy          global toolpath
887 gcpy          print("Entering n toolpath")
888 gcpy          tpzinc = tpzreldim / (barc - earc)
889 gcpy          cts = self.currenttoolshape
890 gcpy          toolpath = cts

```

```
887 gcpy #         toolpath = toolpath.translate([self.xpos(), self.ypos(),
self.zpos()])
888 gcpy #         toolpath = []
889 gcpy         i = barc
890 gcpy         while i > earc:
891 gcpy             self.cutline(xcenter + radius * Cos(math.radians(i)),
ycenter + radius * Sin(math.radians(i)), self.zpos()
+tpzinc)
892 gcpy #             self.setxpos(xcenter + radius * Cos(math.radians(i)))
893 gcpy #             self.setypos(ycenter + radius * Sin(math.radians(i)))
894 gcpy #             print(str(self.xpos()), str(self.ypos()), str(self.zpos
()))))
895 gcpy #             self.setzpos(self.zpos()+tpzinc)
896 gcpy             i += abs(stepsizearc) * -1
897 gcpy #             self.dxfarc(self.currenttoolnumber(), xcenter, ycenter,
radius, barc, earc)
898 gcpy #             if self.generatepaths == True:
899 gcpy #                 print("Unioning n toolpath")
900 gcpy #                 self.toolpaths = self.toolpaths.union(toolpath)
901 gcpy #             else:
902 gcpy                 self.setxpos(xcenter + radius * Cos(math.radians(earc)))
903 gcpy                 self.setypos(ycenter + radius * Sin(math.radians(earc)))
904 gcpy #                 self.toolpaths.extend(toolpath)
905 gcpy #                 if self.generatepaths == False:
906 gcpy #                     return toolpath
907 gcpy #                 else:
908 gcpy #                     return cube([0.01, 0.01, 0.01])
```

Note that it will be necessary to add versions which write out a matching DXF element:

```
910 gcpy         def cutarcCWdxf(self, barc, earc, xcenter, ycenter, radius,
tpzreldim, stepsizearc=1):
911 gcpy             self.cutarcCW(barc, earc, xcenter, ycenter, radius,
tpzreldim, stepsizearc=1)
912 gcpy             self.dxfarc(self.currenttoolnumber(), xcenter, ycenter,
radius, earc, barc)
913 gcpy #             if self.generatepaths == False:
914 gcpy #                 return toolpath
915 gcpy #             else:
916 gcpy #                 return cube([0.01, 0.01, 0.01])
917 gcpy
918 gcpy         def cutarcCCdxf(self, barc, earc, xcenter, ycenter, radius,
tpzreldim, stepsizearc=1):
919 gcpy             self.cutarcCC(barc, earc, xcenter, ycenter, radius,
tpzreldim, stepsizearc=1)
920 gcpy             self.dxfarc(self.currenttoolnumber(), xcenter, ycenter,
radius, barc, earc)
```

Matching OpenSCAD modules are easily made:

```
84 gpcpscad module cutarcCC(barc, earc, xcenter, ycenter, radius, tpzreldim){
85 gpcpscad     gcp.cutarcCC(barc, earc, xcenter, ycenter, radius, tpzreldim);
86 gpcpscad }
87 gpcpscad
88 gpcpscad module cutarcCW(barc, earc, xcenter, ycenter, radius, tpzreldim){
89 gpcpscad     gcp.cutarcCW(barc, earc, xcenter, ycenter, radius, tpzreldim);
90 gpcpscad }
```

An alternate interface which matches how G2/G3 arcs are programmed in G-code is a useful option:

```
922 gcpy         def cutquarterCCNE(self, ex, ey, ez, radius):
923 gcpy             if self.zpos() == ez:
924 gcpy                 tpzinc = 0
925 gcpy             else:
926 gcpy                 tpzinc = (ez - self.zpos()) / 90
927 gcpy #             print("tpzinc ", tpzinc)
928 gcpy             i = 1
929 gcpy             while i < 91:
930 gcpy                 self.cutline(ex + radius * Cos(i), ey - radius + radius
* Sin(i), self.zpos()+tpzinc)
931 gcpy                 i += 1
932 gcpy
933 gcpy         def cutquarterCCNW(self, ex, ey, ez, radius):
934 gcpy             if self.zpos() == ez:
935 gcpy                 tpzinc = 0
936 gcpy             else:
```

```

937 gcpy          tpzinc = (ez - self.zpos()) / 90
938 gcpy #        tpzinc = (self.zpos() + ez) / 90
939 gcpy          print("tpzinc_", tpzinc)
940 gcpy          i = 91
941 gcpy          while i < 181:
942 gcpy              self.cutline(ex + radius + radius * Cos(i), ey + radius
                                * Sin(i), self.zpos()+tpzinc)
943 gcpy              i += 1
944 gcpy
945 gcpy          def cutquarterCCSW(self, ex, ey, ez, radius):
946 gcpy              if self.zpos() == ez:
947 gcpy                  tpzinc = 0
948 gcpy              else:
949 gcpy                  tpzinc = (ez - self.zpos()) / 90
950 gcpy #          tpzinc = (self.zpos() + ez) / 90
951 gcpy          print("tpzinc_", tpzinc)
952 gcpy          i = 181
953 gcpy          while i < 271:
954 gcpy              self.cutline(ex + radius * Cos(i), ey + radius + radius
                                * Sin(i), self.zpos()+tpzinc)
955 gcpy              i += 1
956 gcpy
957 gcpy          def cutquarterCCSE(self, ex, ey, ez, radius):
958 gcpy              if self.zpos() == ez:
959 gcpy                  tpzinc = 0
960 gcpy              else:
961 gcpy                  tpzinc = (ez - self.zpos()) / 90
962 gcpy #          tpzinc = (self.zpos() + ez) / 90
963 gcpy #          print("tpzinc ", tpzinc)
964 gcpy          i = 271
965 gcpy          while i < 361:
966 gcpy              self.cutline(ex - radius + radius * Cos(i), ey + radius
                                * Sin(i), self.zpos()+tpzinc)
967 gcpy              i += 1
968 gcpy
969 gcpy          def cutquarterCCNEdx(self, ex, ey, ez, radius):
970 gcpy              self.cutquarterCCNE(ex, ey, ez, radius)
971 gcpy              self.dxfarc(self.currenttoolnumber(), ex, ey - radius,
                                radius, 0, 90)
972 gcpy
973 gcpy          def cutquarterCCNWdx(self, ex, ey, ez, radius):
974 gcpy              self.cutquarterCCNW(ex, ey, ez, radius)
975 gcpy              self.dxfarc(self.currenttoolnumber(), ex + radius, ey,
                                radius, 90, 180)
976 gcpy
977 gcpy          def cutquarterCCSWdx(self, ex, ey, ez, radius):
978 gcpy              self.cutquarterCCSW(ex, ey, ez, radius)
979 gcpy              self.dxfarc(self.currenttoolnumber(), ex, ey + radius,
                                radius, 180, 270)
980 gcpy
981 gcpy          def cutquarterCCSEdx(self, ex, ey, ez, radius):
982 gcpy              self.cutquarterCCSE(ex, ey, ez, radius)
983 gcpy              self.dxfarc(self.currenttoolnumber(), ex - radius, ey,
                                radius, 270, 360)

```

```

92 gcpscad module cutquarterCCNE(ex, ey, ez, radius){
93 gcpscad     gcp.cutquarterCCNE(ex, ey, ez, radius);
94 gcpscad }
95 gcpscad
96 gcpscad module cutquarterCCNW(ex, ey, ez, radius){
97 gcpscad     gcp.cutquarterCCNW(ex, ey, ez, radius);
98 gcpscad }
99 gcpscad
100 gcpscad module cutquarterCCSW(ex, ey, ez, radius){
101 gcpscad     gcp.cutquarterCCSW(ex, ey, ez, radius);
102 gcpscad }
103 gcpscad
104 gcpscad module cutquarterCCSE(self, ex, ey, ez, radius){
105 gcpscad     gcp.cutquarterCCSE(ex, ey, ez, radius);
106 gcpscad }
107 gcpscad
108 gcpscad module cutquarterCCNEdx(ex, ey, ez, radius){
109 gcpscad     gcp.cutquarterCCNEdx(ex, ey, ez, radius);
110 gcpscad }
111 gcpscad
112 gcpscad module cutquarterCCNWdx(ex, ey, ez, radius){
113 gcpscad     gcp.cutquarterCCNWdx(ex, ey, ez, radius);

```



```
114 gcpscad }
115 gcpscad
116 gcpscad module cutquarterCCSWdxf(ex, ey, ez, radius){
117 gcpscad     gcp.cutquarterCCSWdxf(ex, ey, ez, radius);
118 gcpscad }
119 gcpscad
120 gcpscad module cutquarterCCSEdxf(self, ex, ey, ez, radius){
121 gcpscad     gcp.cutquarterCCSEdxf(ex, ey, ez, radius);
122 gcpscad }
```

3.4.3 tooldiameter

It will also be necessary to be able to provide the diameter of the current tool. Arguably, this would be much easier using an object-oriented programming style/dot notation.

One aspect of tool parameters which will need to be supported is shapes which create different profiles based on how deeply the tool is cutting into the surface of the material at a given point. To accommodate this, it will be necessary to either track the thickness of uncut material at any given point, or, to specify the depth of cut as a parameter.

tool diameter The public-facing OpenSCAD code, tool diameter simply calls the matching OpenSCAD module which wraps the Python code:

```
124 gcpscad function tool_diameter(td_tool, td_depth) = otool_diameter(td_tool,
    td_depth);
```

tool diameter the Python code, tool diameter returns appropriate values based on the specified tool number and depth:

```
985 gcpy         def tool_diameter(self, ptd_tool, ptd_depth):
986 gcpy # Square 122, 112, 102, 201
987 gcpy         if ptd_tool == 122:
988 gcpy             return 0.79375
989 gcpy         if ptd_tool == 112:
990 gcpy             return 1.5875
991 gcpy         if ptd_tool == 102:
992 gcpy             return 3.175
993 gcpy         if ptd_tool == 201:
994 gcpy             return 6.35
995 gcpy # Ball 121, 111, 101, 202
996 gcpy         if ptd_tool == 122:
997 gcpy             if ptd_depth > 0.396875:
998 gcpy                 return 0.79375
999 gcpy             else:
1000 gcpy                 return ptd_tool
1001 gcpy         if ptd_tool == 112:
1002 gcpy             if ptd_depth > 0.79375:
1003 gcpy                 return 1.5875
1004 gcpy             else:
1005 gcpy                 return ptd_tool
1006 gcpy         if ptd_tool == 101:
1007 gcpy             if ptd_depth > 1.5875:
1008 gcpy                 return 3.175
1009 gcpy             else:
1010 gcpy                 return ptd_tool
1011 gcpy         if ptd_tool == 202:
1012 gcpy             if ptd_depth > 3.175:
1013 gcpy                 return 6.35
1014 gcpy             else:
1015 gcpy                 return ptd_tool
1016 gcpy # V 301, 302, 390
1017 gcpy         if ptd_tool == 301:
1018 gcpy             return ptd_tool
1019 gcpy         if ptd_tool == 302:
1020 gcpy             return ptd_tool
1021 gcpy         if ptd_tool == 390:
1022 gcpy             return ptd_tool
1023 gcpy # Keyhole
1024 gcpy         if ptd_tool == 374:
1025 gcpy             if ptd_depth < 3.175:
1026 gcpy                 return 9.525
1027 gcpy             else:
1028 gcpy                 return 6.35
1029 gcpy         if ptd_tool == 375:
1030 gcpy             if ptd_depth < 3.175:
1031 gcpy                 return 9.525
1032 gcpy             else:
1033 gcpy                 return 8
```

```
1034 gcpy          if ptd_tool == 376:
1035 gcpy              if ptd_depth < 4.7625:
1036 gcpy                  return 12.7
1037 gcpy              else:
1038 gcpy                  return 6.35
1039 gcpy          if ptd_tool == 378:
1040 gcpy              if ptd_depth < 4.7625:
1041 gcpy                  return 12.7
1042 gcpy              else:
1043 gcpy                  return 8
1044 gcpy # Dovetail
1045 gcpy          if ptd_tool == 814:
1046 gcpy              if ptd_depth > 12.7:
1047 gcpy                  return 6.35
1048 gcpy              else:
1049 gcpy                  return ptd_tool
1050 gcpy          if ptd_tool == 808079:
1051 gcpy              if ptd_depth > 20.95:
1052 gcpy                  return 6.816
1053 gcpy              else:
1054 gcpy                  return ptd_tool
1055 gcpy # Bowl Bit
1056 gcpy #https://www.amanatool.com/45982-carbide-tipped-bowl-tray-1-4-
           radius-x-3-4-dia-x-5-8-x-1-4-inch-shank.html
1057 gcpy          if ptd_tool == 45982:
1058 gcpy              if ptd_depth > 6.35:
1059 gcpy                  return 15.875
1060 gcpy              else:
1061 gcpy                  return ptd_tool
1062 gcpy # Tapered Ball Nose
1063 gcpy          if ptd_tool == 204:
1064 gcpy              if ptd_depth > 6.35:
1065 gcpy                  return ptd_tool
1066 gcpy          if ptd_tool == 304:
1067 gcpy              if ptd_depth > 6.35:
1068 gcpy                  return ptd_tool
1069 gcpy              else:
1070 gcpy                  return ptd_tool
```

tool radius Since it is often necessary to utilise the radius of the tool, an additional command, tool radius to return this value is worthwhile:

```
1072 gcpy          def tool_radius(self, ptd_tool, ptd_depth):
1073 gcpy              tr = self.tool_diameter(ptd_tool, ptd_depth)/2
1074 gcpy              return tr
```

(Note that where values are not fully calculated values currently the passed in tool number (ptd tool)is returned which will need to be replaced with code which calculates the appropriate values.)

3.4.4 Feeds and Speeds

feed There are several possibilities for handling feeds and speeds. Currently, base values for feed, plunge plunge, and speed are used, which may then be adjusted using various <tooldescriptor>_ratio speed values, as an acknowledgement of the likelihood of a trim router being used as a spindle, the assumption is that the speed will remain unchanged.

The tools which need to be calculated thus are those in addition to the large_square tool:

- small_square_ratio
- small_ball_ratio
- large_ball_ratio
- small_V_ratio
- large_V_ratio
- KH_ratio
- DT_ratio

3.5 Difference of Stock, Rapids, and Toolpaths

At the end of cutting it will be necessary to subtract the accumulated toolpaths and rapids from the stock.

For Python, the initial 3D model is stored in the variable stock:

```
1076 gcpy      def stockandtoolpaths(self, option = "stockandtoolpaths"):
1077 gcpy          if option == "stock":
1078 gcpy              show(self.stock)
1079 gcpy          elif option == "toolpaths":
1080 gcpy              show(self.toolpaths)
1081 gcpy          elif option == "rapids":
1082 gcpy              show(self.rapids)
1083 gcpy          else:
1084 gcpy              part = self.stock.difference(self.rapids)
1085 gcpy              part = self.stock.difference(self.toolpaths)
1086 gcpy              show(part)
```

Note that because of the differences in behaviour between OpenPythonSCAD (the `show()` command results in an explicit display of the requested element) and OpenSCAD (there is an implicit mechanism where the 3D element whihc is returned is displayed), the most expedient mechanism is to have an explicit Python command which returns the 3D model:

```
1088 gcpy      def returnstockandtoolpaths(self):
1089 gcpy          part = self.stock.difference(self.toolpaths)
1090 gcpy          return part
```

and then make use of that specific command for OpenSCAD:

```
126 gpcscad module stockandtoolpaths(){
127 gpcscad     gcp.returnstockandtoolpaths();
128 gpcscad }
```

forgoing the options of showing toolpaths and/or rapids separately.

3.6 Output files

The `gcodepreview` class will write out DXF and/or G-code files.

3.6.1 Python and OpenSCAD File Handling

The class `gcodepreview` will need additional commands for opening files. The original implementation in RapSCAD used a command `writeln` — fortunately, this command is easily re-created in Python, though it is made as a separate file for each sort of file which may be opened. Note that the `dxf` commands will be wrapped up with `if/elif` blocks which will write to additional file(s) based on tool number as set up above.

```
1092 gcpy      def writegc(self, *arguments):
1093 gcpy          if self.generategcode == True:
1094 gcpy              line_to_write = ""
1095 gcpy              for element in arguments:
1096 gcpy                  line_to_write += element
1097 gcpy              self.gc.write(line_to_write)
1098 gcpy              self.gc.write("\n")
1099 gcpy
1100 gcpy      def writedxf(self, toolnumber, *arguments):
1101 gcpy          # global dxfclosed
1102 gcpy          line_to_write = ""
1103 gcpy          for element in arguments:
1104 gcpy              line_to_write += element
1105 gcpy          if self.generateddxf == True:
1106 gcpy              if self.dxfclosed == False:
1107 gcpy                  self.dxf.write(line_to_write)
1108 gcpy                  self.dxf.write("\n")
1109 gcpy          if self.generateddxfs == True:
1110 gcpy              self.writedxfs(toolnumber, line_to_write)
1111 gcpy
1112 gcpy      def writedxfs(self, toolnumber, line_to_write):
1113 gcpy          # print("Processing writing toolnumber", toolnumber)
1114 gcpy          # line_to_write = ""
1115 gcpy          # for element in arguments:
1116 gcpy          #     line_to_write += element
1117 gcpy          if (toolnumber == 0):
1118 gcpy              return
1119 gcpy          elif self.generateddxfs == True:
1120 gcpy              if (self.large_square_tool_num == toolnumber):
1121 gcpy                  self.dxfllsq.write(line_to_write)
1122 gcpy                  self.dxfllsq.write("\n")
1123 gcpy              if (self.small_square_tool_num == toolnumber):
1124 gcpy                  self.dxfmsq.write(line_to_write)
1125 gcpy                  self.dxfmsq.write("\n")
```

```
1126 gcpy          if (self.large_ball_tool_num == toolnumber):
1127 gcpy              self.dxflgbl.write(line_to_write)
1128 gcpy              self.dxflgbl.write("\n")
1129 gcpy          if (self.small_ball_tool_num == toolnumber):
1130 gcpy              self.dxfsmbl.write(line_to_write)
1131 gcpy              self.dxfsmbl.write("\n")
1132 gcpy          if (self.large_V_tool_num == toolnumber):
1133 gcpy              self.dxflgV.write(line_to_write)
1134 gcpy              self.dxflgV.write("\n")
1135 gcpy          if (self.small_V_tool_num == toolnumber):
1136 gcpy              self.dxfsmV.write(line_to_write)
1137 gcpy              self.dxfsmV.write("\n")
1138 gcpy          if (self.DT_tool_num == toolnumber):
1139 gcpy              self.dxfDT.write(line_to_write)
1140 gcpy              self.dxfDT.write("\n")
1141 gcpy          if (self.KH_tool_num == toolnumber):
1142 gcpy              self.dxfKH.write(line_to_write)
1143 gcpy              self.dxfKH.write("\n")
1144 gcpy          if (self.Roundover_tool_num == toolnumber):
1145 gcpy              self.dxfRt.write(line_to_write)
1146 gcpy              self.dxfRt.write("\n")
1147 gcpy          if (self.MISC_tool_num == toolnumber):
1148 gcpy              self.dxfMt.write(line_to_write)
1149 gcpy              self.dxfMt.write("\n")
```

which commands will accept a series of arguments and then write them out to a file object for the appropriate file. Note that the DXF files for specific tools will expect that the tool numbers be set in the matching variables from the template. Further note that while it is possible to use tools which are not so defined, the toolpaths will not be written into DXF files for any tool numbers which do not match the variables from the template (but will appear in the main .dxf).

opengcodefile For writing to files it will be necessary to have commands for opening the files: opengcodefile
opendxfile and opendxfile which will set the associated defaults. There is a separate function for each type of file, and for DXFs, there are multiple file instances, one for each combination of different type and size of tool which it is expected a project will work with. Each such file will be suffixed with the tool number.

There will need to be matching OpenSCAD modules for the Python functions:

```
130 gcpscad module opendxfile(basefilename){
131 gcpscad     gcp.opendxfile(basefilename);
132 gcpscad }
133 gcpscad
134 gcpscad module opendxfiles(Base_filename, large_square_tool_num,
    small_square_tool_num, large_ball_tool_num, small_ball_tool_num,
    large_V_tool_num, small_V_tool_num, DT_tool_num, KH_tool_num,
    Roundover_tool_num, MISC_tool_num) {
135 gcpscad     gcp.opendxfiles(Base_filename, large_square_tool_num,
    small_square_tool_num, large_ball_tool_num,
    small_ball_tool_num, large_V_tool_num, small_V_tool_num,
    DT_tool_num, KH_tool_num, Roundover_tool_num, MISC_tool_num)
    ;
136 gcpscad }
```

opengcodefile With matching OpenSCAD commands: opengcodefile for OpenSCAD:

```
138 gcpscad module opengcodefile(basefilename, currenttoolnum, toolradius,
    plunge, feed, speed) {
139 gcpscad     gcp.opengcodefile(basefilename, currenttoolnum, toolradius,
    plunge, feed, speed);
140 gcpscad }
```

and Python:

```
1151 gcpy          def opengcodefile(self, basefilename = "export",
1152 gcpy              currenttoolnum = 102,
1153 gcpy              toolradius = 3.175,
1154 gcpy              plunge = 400,
1155 gcpy              feed = 1600,
1156 gcpy              speed = 10000
1157 gcpy              ):
1158 gcpy              self.basefilename = basefilename
1159 gcpy              self.currenttoolnum = currenttoolnum
1160 gcpy              self.toolradius = toolradius
1161 gcpy              self.plunge = plunge
1162 gcpy              self.feed = feed
1163 gcpy              self.speed = speed
1164 gcpy              if self.generategcode == True:
```

```

1165 gcpy          self.gcodefilename = basefilename + ".nc"
1166 gcpy          self.gc = open(self.gcodefilename, "w")
1167 gcpy          self.writegc("(Design_File: " + self.basefilename + ")")
1168 gcpy
1169 gcpy          def opendxfile(self, basefilename = "export"):
1170 gcpy              self.basefilename = basefilename
1171 gcpy              global generatedxfs
1172 gcpy              global dxfclosed
1173 gcpy              self.dxfclosed = False
1174 gcpy              self.dxfcolor = "Black"
1175 gcpy              if self.generatedxif == True:
1176 gcpy                  self.generatedxfs = False
1177 gcpy                  self.dxfilename = basefilename + ".dxf"
1178 gcpy                  self.dxf = open(self.dxfilename, "w")
1179 gcpy                  self.dxfpreamble(-1)
1180 gcpy
1181 gcpy          def opendxfiles(self, basefilename = "export",
1182 gcpy                          large_square_tool_num = 0,
1183 gcpy                          small_square_tool_num = 0,
1184 gcpy                          large_ball_tool_num = 0,
1185 gcpy                          small_ball_tool_num = 0,
1186 gcpy                          large_V_tool_num = 0,
1187 gcpy                          small_V_tool_num = 0,
1188 gcpy                          DT_tool_num = 0,
1189 gcpy                          KH_tool_num = 0,
1190 gcpy                          Roundover_tool_num = 0,
1191 gcpy                          MISC_tool_num = 0):
1192 gcpy              global generatedxfs
1193 gcpy              self.basefilename = basefilename
1194 gcpy              self.generatedxfs = True
1195 gcpy              self.large_square_tool_num = large_square_tool_num
1196 gcpy              self.small_square_tool_num = small_square_tool_num
1197 gcpy              self.large_ball_tool_num = large_ball_tool_num
1198 gcpy              self.small_ball_tool_num = small_ball_tool_num
1199 gcpy              self.large_V_tool_num = large_V_tool_num
1200 gcpy              self.small_V_tool_num = small_V_tool_num
1201 gcpy              self.DT_tool_num = DT_tool_num
1202 gcpy              self.KH_tool_num = KH_tool_num
1203 gcpy              self.Roundover_tool_num = Roundover_tool_num
1204 gcpy              self.MISC_tool_num = MISC_tool_num
1205 gcpy              if self.generatedxif == True:
1206 gcpy                  if (large_square_tool_num > 0):
1207 gcpy                      self.dxfllgsqfilename = basefilename + str(
1208 gcpy                          large_square_tool_num) + ".dxf"
1209 gcpy                      print("Opening ", str(self.dxfllgsqfilename))
1210 gcpy                      self.dxfllgsq = open(self.dxfllgsqfilename, "w")
1211 gcpy                  if (small_square_tool_num > 0):
1212 gcpy                      print("Opening small square")
1213 gcpy                      self.dxfllmsqfilename = basefilename + str(
1214 gcpy                          small_square_tool_num) + ".dxf"
1215 gcpy                      self.dxfllmsq = open(self.dxfllmsqfilename, "w")
1216 gcpy                  if (large_ball_tool_num > 0):
1217 gcpy                      print("Opening large ball")
1218 gcpy                      self.dxfllgblfilename = basefilename + str(
1219 gcpy                          large_ball_tool_num) + ".dxf"
1220 gcpy                      self.dxfllgbl = open(self.dxfllgblfilename, "w")
1221 gcpy                  if (small_ball_tool_num > 0):
1222 gcpy                      print("Opening small ball")
1223 gcpy                      self.dxfllsblfilename = basefilename + str(
1224 gcpy                          small_ball_tool_num) + ".dxf"
1225 gcpy                      self.dxfllsbl = open(self.dxfllsblfilename, "w")
1226 gcpy                  if (large_V_tool_num > 0):
1227 gcpy                      print("Opening large V")
1228 gcpy                      self.dxfllgVfilename = basefilename + str(
1229 gcpy                          large_V_tool_num) + ".dxf"
1230 gcpy                      self.dxfllgV = open(self.dxfllgVfilename, "w")
1231 gcpy                  if (small_V_tool_num > 0):
1232 gcpy                      print("Opening small V")
1233 gcpy                      self.dxfllsVfilename = basefilename + str(
1234 gcpy                          small_V_tool_num) + ".dxf"
1235 gcpy                      self.dxfllsV = open(self.dxfllsVfilename, "w")
1236 gcpy                  if (DT_tool_num > 0):
1237 gcpy                      print("Opening DT")
1238 gcpy                      self.dxfllDTfilename = basefilename + str(DT_tool_num)
1239 gcpy                      + ".dxf"
1240 gcpy                      self.dxfllDT = open(self.dxfllDTfilename, "w")
1241 gcpy                  if (KH_tool_num > 0):

```

```
1235 gcpy #           print("Opening KH")
1236 gcpy           self.dxfKHfilename = basefilename + str(KH_tool_num
                    ) + ".dxf"
1237 gcpy           self.dxfKH = open(self.dxfKHfilename, "w")
1238 gcpy           if (Roundover_tool_num > 0):
1239 gcpy #             print("Opening Rt")
1240 gcpy             self.dxfRtfilename = basefilename + str(
                    Roundover_tool_num) + ".dxf"
1241 gcpy             self.dxfRt = open(self.dxfRtfilename, "w")
1242 gcpy           if (MISC_tool_num > 0):
1243 gcpy #             print("Opening Mt")
1244 gcpy             self.dxfMtfilename = basefilename + str(
                    MISC_tool_num) + ".dxf"
1245 gcpy             self.dxfMt = open(self.dxfMtfilename, "w")
```

For each DXF file, there will need to be a Preamble in addition to opening the file in the file system:

```
1246 gcpy           if (large_square_tool_num > 0):
1247 gcpy               self.dxfpreamble(large_square_tool_num)
1248 gcpy           if (small_square_tool_num > 0):
1249 gcpy               self.dxfpreamble(small_square_tool_num)
1250 gcpy           if (large_ball_tool_num > 0):
1251 gcpy               self.dxfpreamble(large_ball_tool_num)
1252 gcpy           if (small_ball_tool_num > 0):
1253 gcpy               self.dxfpreamble(small_ball_tool_num)
1254 gcpy           if (large_V_tool_num > 0):
1255 gcpy               self.dxfpreamble(large_V_tool_num)
1256 gcpy           if (small_V_tool_num > 0):
1257 gcpy               self.dxfpreamble(small_V_tool_num)
1258 gcpy           if (DT_tool_num > 0):
1259 gcpy               self.dxfpreamble(DT_tool_num)
1260 gcpy           if (KH_tool_num > 0):
1261 gcpy               self.dxfpreamble(KH_tool_num)
1262 gcpy           if (Roundover_tool_num > 0):
1263 gcpy               self.dxfpreamble(Roundover_tool_num)
1264 gcpy           if (MISC_tool_num > 0):
1265 gcpy               self.dxfpreamble(MISC_tool_num)
```

Note that the commands which interact with files include checks to see if said files are being generated.

Future considerations:

- Multiple Preview Modes:
- Fast Preview: Write all movements with both begin and end positions into a list for a specific tool — as this is done, check for a previous movement between those positions and compare depths and tool number — keep only the deepest movement for a given tool.
- Motion Preview: Work up a 3D model of the machine and actually show the stock in relation to it,

3.6.2 DXF Overview

Elements in DXFs are represented as lines or arcs. A minimal file showing both:

```
0
SECTION
2
ENTITIES
0
LWPOLYLINE
90
2
70
0
43
0
10
-31.375
20
-34.9152
10
-31.375
20
-18.75
0
ARC
```

```
10
-54.75
20
-37.5
40
4
50
0
51
90
0
ENDSEC
0
EOF
```

3.6.2.1 Writing to DXF files When the command to open .dxf files is called it is passed all of the variables for the various tool types/sizes, and based on a value being greater than zero, the matching file is opened, and in addition, the main dxf which is always written to is opened as well. On the gripping hand, each element which may be written to a dxf file will have a user module as well as an internal module which will be called by it so as to write to the file for the current tool. It will be necessary for the dxfwrite command to evaluate the tool number which is passed in, and to use an appropriate command or set of commands to then write out to the appropriate file for a given tool (if positive) or not do anything (if zero), and to write to the master file if a negative value is passed in (this allows the various DXF template commands to be written only once and then called at need).

Each tool has a matching command for each tool/size combination:

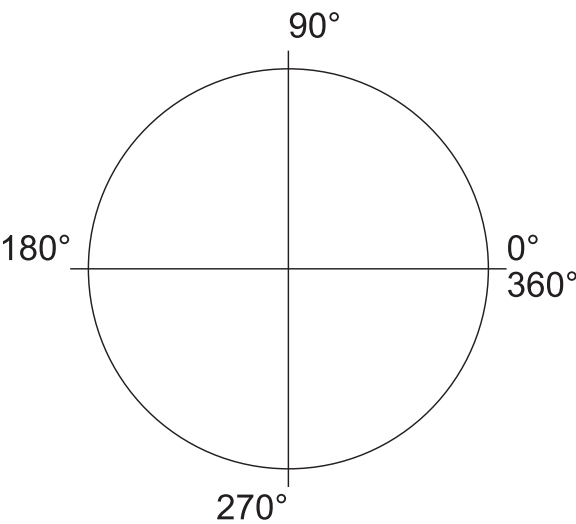
writedxflgbl	• Ball nose, large (lgbl) writedxflgbl
writedxfsmb1	• Ball nose, small (smb1) writedxfsmb1
writedxflgsq	• Square, large (lgsq) writedxflgsq
writedxfsmsq	• Square, small (smsq) writedxfsmsq
writedxflgV	• V, large (lgV) writedxflgV
writedxfsmV	• V, small (smV) writedxfsmV
writedxfKH	• Keyhole (KH) writedxfKH
writedxfDT	• Dovetail (DT) writedxfDT
dxfpreamble	This module requires that the tool number be passed in, and after writing out dxfpreamble, that value will be used to write out to the appropriate file with a series of if statements.

```
1267 gcpy      def dxfpreamble(self, tn):
1268 gcpy #          self.writedxf(tn, str(tn))
1269 gcpy          self.writedxf(tn, "0")
1270 gcpy          self.writedxf(tn, "SECTION")
1271 gcpy          self.writedxf(tn, "2")
1272 gcpy          self.writedxf(tn, "ENTITIES")
```

3.6.2.1.1 DXF Lines and Arcs There are several elements which may be written to a DXF:

dxfline	• a line dxfline
beginpolyline	• connected lines beginpolyline/addvertex/closepolyline
addvertex	
closepolyline	• arc dxfarc
dxfarc	
dxfcircle	• circle — a notable option would be for the arc to close on itself, creating a circle dxfcircle

DXF orders arcs counter-clockwise:



Note that arcs of greater than 90 degrees are not rendered accurately (in certain applications at least), so, for the sake of precision, they should be limited to a swing of 90 degrees or less. Further note that 4 arcs may be stitched together to make a circle:

```
dxffarc(10, 10, 5, 0, 90, small_square_tool_num);
dxffarc(10, 10, 5, 90, 180, small_square_tool_num);
dxffarc(10, 10, 5, 180, 270, small_square_tool_num);
dxffarc(10, 10, 5, 270, 360, small_square_tool_num);
```

The DXF file format supports colors defined by AutoCAD’s indexed color system:

Color Code	Color Name
0	Black (or Foreground)
1	Red
2	Yellow
3	Green
4	Cyan
5	Blue
6	Magenta
7	White (or Background)
8	Dark Gray
9	Light Gray

Color codes 10–255 represent additional colors, with hues varying based on RGB values. Obviously, a command to manage adding the color commands would be:

```
1274 gcpy      def setdxffcolor(self, color):
1275 gcpy          self.dxffcolor = color
1276 gcpy          self.cutcolor = color
1277 gcpy
1278 gcpy      def writedxffcolor(self, tn):
1279 gcpy          self.writedxff(tn, "8")
1280 gcpy          if (self.dxffcolor == "Black"):
1281 gcpy              self.writedxff(tn, "Layer_Black")
1282 gcpy          if (self.dxffcolor == "Red"):
1283 gcpy              self.writedxff(tn, "Layer_Red")
1284 gcpy          if (self.dxffcolor == "Yellow"):
1285 gcpy              self.writedxff(tn, "Layer_Yellow")
1286 gcpy          if (self.dxffcolor == "Green"):
1287 gcpy              self.writedxff(tn, "Layer_Green")
1288 gcpy          if (self.dxffcolor == "Cyan"):
1289 gcpy              self.writedxff(tn, "Layer_Cyan")
1290 gcpy          if (self.dxffcolor == "Blue"):
1291 gcpy              self.writedxff(tn, "Layer_Blue")
1292 gcpy          if (self.dxffcolor == "Magenta"):
1293 gcpy              self.writedxff(tn, "Layer_Magenta")
1294 gcpy          if (self.dxffcolor == "White"):
1295 gcpy              self.writedxff(tn, "Layer_White")
1296 gcpy          if (self.dxffcolor == "Dark_Gray"):
1297 gcpy              self.writedxff(tn, "Layer_Dark_Gray")
1298 gcpy          if (self.dxffcolor == "Light_Gray"):
1299 gcpy              self.writedxff(tn, "Layer_Light_Gray")
1300 gcpy
1301 gcpy          self.writedxff(tn, "62")
1302 gcpy          if (self.dxffcolor == "Black"):
1303 gcpy              self.writedxff(tn, "0")
1304 gcpy          if (self.dxffcolor == "Red"):
1305 gcpy              self.writedxff(tn, "1")
```



```
1306 gcpy          if (self.dxfcolor == "Yellow"):
1307 gcpy              self.writedxf(tn, "2")
1308 gcpy          if (self.dxfcolor == "Green"):
1309 gcpy              self.writedxf(tn, "3")
1310 gcpy          if (self.dxfcolor == "Cyan"):
1311 gcpy              self.writedxf(tn, "4")
1312 gcpy          if (self.dxfcolor == "Blue"):
1313 gcpy              self.writedxf(tn, "5")
1314 gcpy          if (self.dxfcolor == "Magenta"):
1315 gcpy              self.writedxf(tn, "6")
1316 gcpy          if (self.dxfcolor == "White"):
1317 gcpy              self.writedxf(tn, "7")
1318 gcpy          if (self.dxfcolor == "Dark_Gray"):
1319 gcpy              self.writedxf(tn, "8")
1320 gcpy          if (self.dxfcolor == "Light_Gray"):
1321 gcpy              self.writedxf(tn, "9")

```

```
142 gpcscad module setdxfcolor(color){
143 gpcscad     gcp.setdxfcolor(color);
144 gpcscad }
```

A further refinement would be to connect multiple line segments/arcs into a larger polyline, but since most CAM tools implicitly join elements on import, that is not necessary. There are three possible interactions for DXF elements and toolpaths:

- describe the motion of the tool
- define a perimeter of an area which will be cut by a tool
- define a centerpoint for a specialty toolpath such as Drill or Keyhole

and it is possible that multiple such elements could be instantiated for a given toolpath. When writing out to a DXF file there is a pair of commands, a public facing command which takes in a tool number in addition to the coordinates which then writes out to the main DXF file and then calls an internal command to which repeats the call with the tool number so as to write it out to the matching file.

```
1323 gcpy      def dxfline(self, tn, xbegin, ybegin, xend, yend):
1324 gcpy          self.writedxf(tn, "0")
1325 gcpy          self.writedxf(tn, "LINE")
1326 gcpy #
1327 gcpy          self.writedxfcolor(tn)
1328 gcpy #
1329 gcpy          self.writedxf(tn, "10")
1330 gcpy          self.writedxf(tn, str(xbegin))
1331 gcpy          self.writedxf(tn, "20")
1332 gcpy          self.writedxf(tn, str(ybegin))
1333 gcpy          self.writedxf(tn, "30")
1334 gcpy          self.writedxf(tn, "0.0")
1335 gcpy          self.writedxf(tn, "11")
1336 gcpy          self.writedxf(tn, str(xend))
1337 gcpy          self.writedxf(tn, "21")
1338 gcpy          self.writedxf(tn, str(yend))
1339 gcpy          self.writedxf(tn, "31")
1340 gcpy          self.writedxf(tn, "0.0")

```

In addition to dxfline which allows creating a line without consideration of context, there is also a dxfpolyline which will create a continuous/joined sequence of line segments which requires beginning it, adding vertexes, and then when done, ending the sequence. First, begin the polyline:

```
1342 gcpy      def beginpolyline(self, tn):#, xbegin, ybegin
1343 gcpy          self.writedxf(tn, "0")
1344 gcpy          self.writedxf(tn, "POLYLINE")
1345 gcpy          self.writedxf(tn, "8")
1346 gcpy          self.writedxf(tn, "default")
1347 gcpy          self.writedxf(tn, "66")
1348 gcpy          self.writedxf(tn, "1")
1349 gcpy #
1350 gcpy          self.writedxfcolor(tn)
1351 gcpy #
1352 gcpy #          self.writedxf(tn, "10")
1353 gcpy #          self.writedxf(tn, str(xbegin))
1354 gcpy #          self.writedxf(tn, "20")
1355 gcpy #          self.writedxf(tn, str(ybegin))
1356 gcpy #          self.writedxf(tn, "30")

```

```
1357 gcpy #          self.writedxf(tn, "0.0")
1358 gcpy          self.writedxf(tn, "70")
1359 gcpy          self.writedxf(tn, "0")
```

then add as many vertexes as are wanted:

```
1361 gcpy      def addvertex(self, tn, xend, yend):
1362 gcpy          self.writedxf(tn, "0")
1363 gcpy          self.writedxf(tn, "VERTEX")
1364 gcpy          self.writedxf(tn, "8")
1365 gcpy          self.writedxf(tn, "default")
1366 gcpy          self.writedxf(tn, "70")
1367 gcpy          self.writedxf(tn, "32")
1368 gcpy          self.writedxf(tn, "10")
1369 gcpy          self.writedxf(tn, str(xend))
1370 gcpy          self.writedxf(tn, "20")
1371 gcpy          self.writedxf(tn, str(yend))
1372 gcpy          self.writedxf(tn, "30")
1373 gcpy          self.writedxf(tn, "0.0")
```

then end the sequence:

```
1375 gcpy      def closepolyline(self, tn):
1376 gcpy          self.writedxf(tn, "0")
1377 gcpy          self.writedxf(tn, "SEQEND")
```

For arcs, there are specific commands for writing out the DXF and G-code files. Note that for the G-code version it will be necessary to calculate the end-position, and to determine if the arc is clockwise or no (G2 vs. G3).

```
1379 gcpy      def dxfarc(self, tn, xcenter, ycenter, radius, anglebegin,
                        endangle):
1380 gcpy          if (self.generatedxif == True):
1381 gcpy              self.writedxf(tn, "0")
1382 gcpy              self.writedxf(tn, "ARC")
1383 gcpy #
1384 gcpy          self.writedxfcolor(tn)
1385 gcpy #
1386 gcpy          self.writedxf(tn, "10")
1387 gcpy          self.writedxf(tn, str(xcenter))
1388 gcpy          self.writedxf(tn, "20")
1389 gcpy          self.writedxf(tn, str(ycenter))
1390 gcpy          self.writedxf(tn, "40")
1391 gcpy          self.writedxf(tn, str(radius))
1392 gcpy          self.writedxf(tn, "50")
1393 gcpy          self.writedxf(tn, str(anglebegin))
1394 gcpy          self.writedxf(tn, "51")
1395 gcpy          self.writedxf(tn, str(endangle))
1396 gcpy
1397 gcpy      def gcdearc(self, tn, xcenter, ycenter, radius, anglebegin,
                        endangle):
1398 gcpy          if (self.generategcode == True):
1399 gcpy              self.writegc(tn, "(0)")
```

The various textual versions are quite obvious, and due to the requirements of G-code, it is straight-forward to include the G-code in them if it is wanted.

```
1401 gcpy      def cutarcNECCdxf(self, ex, ey, ez, xcenter, ycenter, radius):
1402 gcpy #          global toolpath
1403 gcpy #          toolpath = self.currenttool()
1404 gcpy #          toolpath = toolpath.translate([self.xpos(), self.ypos(),
self.zpos()])
1405 gcpy          self.dxfarc(self.currenttoolnumber(), xcenter, ycenter,
                        radius, 0, 90)
1406 gcpy          if (self.zpos == ez):
1407 gcpy              self.settzpos(0)
1408 gcpy          else:
1409 gcpy              self.settzpos((self.zpos()-ez)/90)
1410 gcpy #          self.setxpos(ex)
1411 gcpy #          self.setypos(ey)
1412 gcpy #          self.setzpos(ez)
1413 gcpy #          if self.generatepaths == True:
1414 gcpy #              print("Unioning cutarcNECCdxf toolpath")
1415 gcpy          self.arcloop(1, 90, xcenter, ycenter, radius)
1416 gcpy #          self.toolpaths = self.toolpaths.union(toolpath)
1417 gcpy #          else:
```

```

1418 gcpy #             toolpath = self.arcloop(1, 90, xcenter, ycenter,
radius)
1419 gcpy #             print("Returning cutarcNECCdxf toolpath")
1420 gcpy             return toolpath
1421 gcpy
1422 gcpy     def cutarcNWCCdxf(self, ex, ey, ez, xcenter, ycenter, radius):
1423 gcpy #         global toolpath
1424 gcpy #         toolpath = self.currentttool()
1425 gcpy #         toolpath = toolpath.translate([self.xpos(), self.ypos(),
self.zpos()])
1426 gcpy         self.dxfarc(self.currenttoolnumber(), xcenter, ycenter,
radius, 90, 180)
1427 gcpy         if (self.zpos == ez):
1428 gcpy             self.settzpos(0)
1429 gcpy         else:
1430 gcpy             self.settzpos((self.zpos()-ez)/90)
1431 gcpy #         self.setxpos(ex)
1432 gcpy #         self.setypos(ey)
1433 gcpy #         self.setzpos(ez)
1434 gcpy #         if self.generatepaths == True:
1435 gcpy #             self.arcloop(91, 180, xcenter, ycenter, radius)
1436 gcpy #             self.toolpaths = self.toolpaths.union(toolpath)
1437 gcpy #         else:
1438 gcpy             toolpath = self.arcloop(91, 180, xcenter, ycenter, radius)
1439 gcpy             return toolpath
1440 gcpy
1441 gcpy     def cutarcSWCCdxf(self, ex, ey, ez, xcenter, ycenter, radius):
1442 gcpy #         global toolpath
1443 gcpy #         toolpath = self.currentttool()
1444 gcpy #         toolpath = toolpath.translate([self.xpos(), self.ypos(),
self.zpos()])
1445 gcpy         self.dxfarc(self.currenttoolnumber(), xcenter, ycenter,
radius, 180, 270)
1446 gcpy         if (self.zpos == ez):
1447 gcpy             self.settzpos(0)
1448 gcpy         else:
1449 gcpy             self.settzpos((self.zpos()-ez)/90)
1450 gcpy #         self.setxpos(ex)
1451 gcpy #         self.setypos(ey)
1452 gcpy #         self.setzpos(ez)
1453 gcpy         if self.generatepaths == True:
1454 gcpy             self.arcloop(181, 270, xcenter, ycenter, radius)
1455 gcpy #             self.toolpaths = self.toolpaths.union(toolpath)
1456 gcpy         else:
1457 gcpy             toolpath = self.arcloop(181, 270, xcenter, ycenter,
radius)
1458 gcpy             return toolpath
1459 gcpy
1460 gcpy     def cutarcSECCdxf(self, ex, ey, ez, xcenter, ycenter, radius):
1461 gcpy #         global toolpath
1462 gcpy #         toolpath = self.currentttool()
1463 gcpy #         toolpath = toolpath.translate([self.xpos(), self.ypos(),
self.zpos()])
1464 gcpy         self.dxfarc(self.currenttoolnumber(), xcenter, ycenter,
radius, 270, 360)
1465 gcpy         if (self.zpos == ez):
1466 gcpy             self.settzpos(0)
1467 gcpy         else:
1468 gcpy             self.settzpos((self.zpos()-ez)/90)
1469 gcpy #         self.setxpos(ex)
1470 gcpy #         self.setypos(ey)
1471 gcpy #         self.setzpos(ez)
1472 gcpy         if self.generatepaths == True:
1473 gcpy             self.arcloop(271, 360, xcenter, ycenter, radius)
1474 gcpy #             self.toolpaths = self.toolpaths.union(toolpath)
1475 gcpy         else:
1476 gcpy             toolpath = self.arcloop(271, 360, xcenter, ycenter,
radius)
1477 gcpy             return toolpath
1478 gcpy
1479 gcpy     def cutarcNECWdxf(self, ex, ey, ez, xcenter, ycenter, radius):
1480 gcpy #         global toolpath
1481 gcpy #         toolpath = self.currentttool()
1482 gcpy #         toolpath = toolpath.translate([self.xpos(), self.ypos(),
self.zpos()])
1483 gcpy         self.dxfarc(self.currenttoolnumber(), xcenter, ycenter,
radius, 0, 90)
1484 gcpy         if (self.zpos == ez):

```

```

1485 gcpy          self.settzpos(0)
1486 gcpy      else:
1487 gcpy          self.settzpos((self.zpos()-ez)/90)
1488 gcpy #          self.setxpos(ex)
1489 gcpy #          self.setypos(ey)
1490 gcpy #          self.setzpos(ez)
1491 gcpy      if self.generatepaths == True:
1492 gcpy          self.narcloop(89, 0, xcenter, ycenter, radius)
1493 gcpy #          self.toolpaths = self.toolpaths.union(toolpath)
1494 gcpy      else:
1495 gcpy          toolpath = self.narcloop(89, 0, xcenter, ycenter,
1496 gcpy              radius)
1497 gcpy          return toolpath
1498 gcpy      def cutarcSECWdx(self, ex, ey, ez, xcenter, ycenter, radius):
1499 gcpy #          global toolpath
1500 gcpy #          toolpath = self.currenttool()
1501 gcpy #          toolpath = toolpath.translate([self.xpos(), self.ypos(),
1502 gcpy #              self.zpos()])
1503 gcpy          self.dxfarc(self.currenttoolnumber(), xcenter, ycenter,
1504 gcpy              radius, 270, 360)
1505 gcpy          if (self.zpos == ez):
1506 gcpy              self.settzpos(0)
1507 gcpy          else:
1508 gcpy              self.settzpos((self.zpos()-ez)/90)
1509 gcpy #          self.setxpos(ex)
1510 gcpy #          self.setypos(ey)
1511 gcpy #          self.setzpos(ez)
1512 gcpy      if self.generatepaths == True:
1513 gcpy          self.narcloop(359, 270, xcenter, ycenter, radius)
1514 gcpy #          self.toolpaths = self.toolpaths.union(toolpath)
1515 gcpy      else:
1516 gcpy          toolpath = self.narcloop(359, 270, xcenter, ycenter,
1517 gcpy              radius)
1518 gcpy          return toolpath
1519 gcpy      def cutarcSWCWdx(self, ex, ey, ez, xcenter, ycenter, radius):
1520 gcpy #          global toolpath
1521 gcpy #          toolpath = self.currenttool()
1522 gcpy #          toolpath = toolpath.translate([self.xpos(), self.ypos(),
1523 gcpy #              self.zpos()])
1524 gcpy          self.dxfarc(self.currenttoolnumber(), xcenter, ycenter,
1525 gcpy              radius, 180, 270)
1526 gcpy          if (self.zpos == ez):
1527 gcpy              self.settzpos(0)
1528 gcpy          else:
1529 gcpy              self.settzpos((self.zpos()-ez)/90)
1530 gcpy #          self.setxpos(ex)
1531 gcpy #          self.setypos(ey)
1532 gcpy #          self.setzpos(ez)
1533 gcpy      if self.generatepaths == True:
1534 gcpy          self.narcloop(269, 180, xcenter, ycenter, radius)
1535 gcpy #          self.toolpaths = self.toolpaths.union(toolpath)
1536 gcpy      else:
1537 gcpy          toolpath = self.narcloop(269, 180, xcenter, ycenter,
1538 gcpy              radius)
1539 gcpy          return toolpath
1540 gcpy      def cutarcNWCWdx(self, ex, ey, ez, xcenter, ycenter, radius):
1541 gcpy #          global toolpath
1542 gcpy #          toolpath = self.currenttool()
1543 gcpy #          toolpath = toolpath.translate([self.xpos(), self.ypos(),
1544 gcpy #              self.zpos()])
1545 gcpy          self.dxfarc(self.currenttoolnumber(), xcenter, ycenter,
1546 gcpy              radius, 90, 180)
1547 gcpy          if (self.zpos == ez):
1548 gcpy              self.settzpos(0)
1549 gcpy          else:
1550 gcpy              self.settzpos((self.zpos()-ez)/90)
1551 gcpy #          self.setxpos(ex)
1552 gcpy #          self.setypos(ey)
1553 gcpy #          self.setzpos(ez)
1554 gcpy      if self.generatepaths == True:
1555 gcpy          self.narcloop(179, 90, xcenter, ycenter, radius)
1556 gcpy #          self.toolpaths = self.toolpaths.union(toolpath)
1557 gcpy      else:
1558 gcpy          toolpath = self.narcloop(179, 90, xcenter, ycenter,
1559 gcpy              radius)

```

```
1553 gcpy                                return toolpath
```

Using such commands to create a circle is quite straight-forward:

```
cutarcNECCdx(-stockXwidth/4, stockYheight/4+stockYheight/16, -stockZthickness, -stockXwidth/4, stockYh
cutarcNWCCdx(-(stockXwidth/4+stockYheight/16), stockYheight/4, -stockZthickness, -stockXwidth/4, stock
cutarcSWCCdx(-stockXwidth/4, stockYheight/4-stockYheight/16, -stockZthickness, -stockXwidth/4, stockYh
cutarcSECCdx(-(stockXwidth/4-stockYheight/16), stockYheight/4, -stockZthickness, -stockXwidth/4, stock
```

```
1555 gcpy      def arcCCgc(self, ex, ey, ez, xcenter, ycenter, radius):
1556 gcpy          self.writegc("G03_X", str(ex), "_Y", str(ey), "_Z", str(ez)
                  , "_R", str(radius))

1557 gcpy
1558 gcpy      def arcCWgc(self, ex, ey, ez, xcenter, ycenter, radius):
1559 gcpy          self.writegc("G02_X", str(ex), "_Y", str(ey), "_Z", str(ez)
                  , "_R", str(radius))
```

The above commands may be called if G-code is also wanted with writing out G-code added:

```
1561 gcpy      def cutarcNECCdxfgc(self, ex, ey, ez, xcenter, ycenter, radius)
1562 gcpy          :
1563 gcpy          self.arcCCgc(ex, ey, ez, xcenter, ycenter, radius)
1564 gcpy          if self.generatepaths == True:
1565 gcpy              self.cutarcNECCdx(ex, ey, ez, xcenter, ycenter, radius
1566 gcpy                  )
1567 gcpy          else:
1568 gcpy              return self.cutarcNECCdx(ex, ey, ez, xcenter, ycenter,
1569 gcpy                  radius)

1567 gcpy      def cutarcNWCCdxfgc(self, ex, ey, ez, xcenter, ycenter, radius)
1568 gcpy          :
1569 gcpy          self.arcCCgc(ex, ey, ez, xcenter, ycenter, radius)
1570 gcpy          if self.generatepaths == False:
1571 gcpy              return self.cutarcNWCCdx(ex, ey, ez, xcenter, ycenter,
1572 gcpy                  radius)

1572 gcpy      def cutarcSWCCdxfgc(self, ex, ey, ez, xcenter, ycenter, radius)
1573 gcpy          :
1574 gcpy          self.arcCCgc(ex, ey, ez, xcenter, ycenter, radius)
1575 gcpy          if self.generatepaths == False:
1576 gcpy              return self.cutarcSWCCdx(ex, ey, ez, xcenter, ycenter,
1577 gcpy                  radius)

1577 gcpy      def cutarcSECCdxfgc(self, ex, ey, ez, xcenter, ycenter, radius)
1578 gcpy          :
1579 gcpy          self.arcCCgc(ex, ey, ez, xcenter, ycenter, radius)
1580 gcpy          if self.generatepaths == False:
1581 gcpy              return self.cutarcSECCdx(ex, ey, ez, xcenter, ycenter,
1582 gcpy                  radius)

1582 gcpy      def cutarcNECWdxfgc(self, ex, ey, ez, xcenter, ycenter, radius)
1583 gcpy          :
1584 gcpy          self.arcCWgc(ex, ey, ez, xcenter, ycenter, radius)
1585 gcpy          if self.generatepaths == False:
1586 gcpy              return self.cutarcNECWdx(ex, ey, ez, xcenter, ycenter,
1587 gcpy                  radius)

1587 gcpy      def cutarcSECWdxfgc(self, ex, ey, ez, xcenter, ycenter, radius)
1588 gcpy          :
1589 gcpy          self.arcCWgc(ex, ey, ez, xcenter, ycenter, radius)
1590 gcpy          if self.generatepaths == False:
1591 gcpy              return self.cutarcSECWdx(ex, ey, ez, xcenter, ycenter,
1592 gcpy                  radius)

1592 gcpy      def cutarcSWCWdxfgc(self, ex, ey, ez, xcenter, ycenter, radius)
1593 gcpy          :
1594 gcpy          self.arcCWgc(ex, ey, ez, xcenter, ycenter, radius)
1595 gcpy          if self.generatepaths == False:
1596 gcpy              return self.cutarcSWCWdx(ex, ey, ez, xcenter, ycenter,
1597 gcpy                  radius)

1597 gcpy      def cutarcNWCWdxfgc(self, ex, ey, ez, xcenter, ycenter, radius)
1598 gcpy          :
1599 gcpy          self.arcCWgc(ex, ey, ez, xcenter, ycenter, radius)
1600 gcpy          if self.generatepaths == False:
1601 gcpy              return self.cutarcNWCWdx(ex, ey, ez, xcenter, ycenter,
1602 gcpy                  radius)
```

```
146 gpcscad module cutarcNECCdxfgc(ex, ey, ez, xcenter, ycenter, radius){
147 gpcscad     gcp.cutarcNECCdxfgc(ex, ey, ez, xcenter, ycenter, radius);
148 gpcscad }
149 gpcscad
150 gpcscad module cutarcNWCCdxfgc(ex, ey, ez, xcenter, ycenter, radius){
151 gpcscad     gcp.cutarcNWCCdxfgc(ex, ey, ez, xcenter, ycenter, radius);
152 gpcscad }
153 gpcscad
154 gpcscad module cutarcSWCCdxfgc(ex, ey, ez, xcenter, ycenter, radius){
155 gpcscad     gcp.cutarcSWCCdxfgc(ex, ey, ez, xcenter, ycenter, radius);
156 gpcscad }
157 gpcscad
158 gpcscad module cutarcSECCdxfgc(ex, ey, ez, xcenter, ycenter, radius){
159 gpcscad     gcp.cutarcSECCdxfgc(ex, ey, ez, xcenter, ycenter, radius);
160 gpcscad }
```

3.6.3 G-code Overview

The G-code commands and their matching modules may include (but are not limited to):

Command/Module	G-code
opengcodefile(s)(...); setupstock(...)	(export.nc) (stockMin: -109.5, -75mm, -8.35mm) (stockMax:109.5mm, 75mm, 0.00mm) (STOCK/BLOCK, 219, 150, 8.35, 109.5, 75, 8.35) G90 G21
movetosafez()	(Move to safe Z to avoid workholding) G53G0Z-5.000
toolchange(...);	(TOOL/MILL, 3.17, 0.00, 0.00, 0.00) M6T102 M03S16000
cutoneaxis_setfeed(...);	(PREPOSITION FOR RAPID PLUNGE) GOXOY0 Z0.25 G1Z0F100 G1 X109.5 Y75 Z-8.35F400 Z9
cutwithfeed(...);	
closegcodefile();	M05 M02

Conversely, the G-code commands which are supported are generated by the following modules:

G-code	Command/Module
(Design File:) (stockMin:0.00mm, -152.40mm, -34.92mm) (stockMax:109.50mm, -77.40mm, 0.00mm) (STOCK/BLOCK, 109.50, 75.00, 34.92, 0.00, 152.40, 34.92) G90 G21	opengcodefile(s)(...); setupstock(.
(Move to safe Z to avoid workholding) G53G0Z-5.000	movetosafez()
(Toolpath: Contour Toolpath 1) M05 (TOOL/MILL, 3.17, 0.00, 0.00, 0.00) M6T102 M03S10000	toolchange(...);
(PREPOSITION FOR RAPID PLUNGE)	writecomment(...)
G0X0.000Y-152.400 Z0.250	rapid(...) rapid(...)
G1Z-1.000F203.2 X109.500Y-77.400F508.0 X57.918Y16.302Z-0.726 Y22.023Z-1.023 X61.190Z-0.681 Y21.643 X57.681 Z12.700	cutwithfeed(...); cutwithfeed(...);
M05 M02	closegcodefile();

The implication here is that it should be possible to read in a G-code file, and for each line/ command instantiate a matching command so as to create a 3D model/preview of the file. This is addressed by making specialized commands for movement which correspond to the various axis combinations (XYZ, XY, XZ, YZ, X, Y, Z).

A further consideration is that rather than hard-coding all possibilities or any changes, having an option for a "post-processor" will be far more flexible.

Described at: <https://carbide3d.com/hub/faq/create-pro-custom-post-processor/> the necessary hooks would be:

- onOpen
- onClose
- onSection (which is where tool changes are defined, since "section" in this case is segmented per tool)

3.6.3.1 Closings

At the end of the program it will be necessary to close each file using the closegcodefile commands: closegcodefile, and closedxffile. In some instances it may be necessary to write additional information, depending on the file format. Note that these commands will need to be within the gcodepreview class.

```
1603 gcpy      def dxfpostamble(self, tn):
1604 gcpy #          self.writedxf(tn, str(tn))
1605 gcpy          self.writedxf(tn, "0")
1606 gcpy          self.writedxf(tn, "ENDSEC")
1607 gcpy          self.writedxf(tn, "0")
1608 gcpy          self.writedxf(tn, "EOF")

1610 gcpy      def gcodepostamble(self):
1611 gcpy          self.writegc("Z12.700")
1612 gcpy          self.writegc("M05")
1613 gcpy          self.writegc("M02")
```

dxfpostamble

It will be necessary to call the dxfpostamble (with appropriate checks and trappings so as to ensure that each dxf file is ended and closed so as to be valid.

```
1615 gcpy      def closegcodefile(self):
1616 gcpy          if self.generategcode == True:
1617 gcpy              self.gcodepostamble()
1618 gcpy              self.gc.close()
1619 gcpy
```

```
1620 gcpy      def closedxfile(self):
1621 gcpy          if self.generatedxf == True:
1622 gcpy #              global dxfclosed
1623 gcpy          self.dxfpostamble(-1)
1624 gcpy #              self.dxfclosed = True
1625 gcpy          self.dxf.close()
1626 gcpy
1627 gcpy      def closedxfiles(self):
1628 gcpy          if self.generatedxfs == True:
1629 gcpy              if (self.large_square_tool_num > 0):
1630 gcpy                  self.dxfpostamble(self.large_square_tool_num)
1631 gcpy              if (self.small_square_tool_num > 0):
1632 gcpy                  self.dxfpostamble(self.small_square_tool_num)
1633 gcpy              if (self.large_ball_tool_num > 0):
1634 gcpy                  self.dxfpostamble(self.large_ball_tool_num)
1635 gcpy              if (self.small_ball_tool_num > 0):
1636 gcpy                  self.dxfpostamble(self.small_ball_tool_num)
1637 gcpy              if (self.large_V_tool_num > 0):
1638 gcpy                  self.dxfpostamble(self.large_V_tool_num)
1639 gcpy              if (self.small_V_tool_num > 0):
1640 gcpy                  self.dxfpostamble(self.small_V_tool_num)
1641 gcpy              if (self.DT_tool_num > 0):
1642 gcpy                  self.dxfpostamble(self.DT_tool_num)
1643 gcpy              if (self.KH_tool_num > 0):
1644 gcpy                  self.dxfpostamble(self.KH_tool_num)
1645 gcpy              if (self.Roundover_tool_num > 0):
1646 gcpy                  self.dxfpostamble(self.Roundover_tool_num)
1647 gcpy              if (self.MISC_tool_num > 0):
1648 gcpy                  self.dxfpostamble(self.MISC_tool_num)
1649 gcpy
1650 gcpy              if (self.large_square_tool_num > 0):
1651 gcpy                  self.dxfclsq.close()
1652 gcpy              if (self.small_square_tool_num > 0):
1653 gcpy                  self.dxfmsq.close()
1654 gcpy              if (self.large_ball_tool_num > 0):
1655 gcpy                  self.dxfclgb.close()
1656 gcpy              if (self.small_ball_tool_num > 0):
1657 gcpy                  self.dxfmsbl.close()
1658 gcpy              if (self.large_V_tool_num > 0):
1659 gcpy                  self.dxfclgV.close()
1660 gcpy              if (self.small_V_tool_num > 0):
1661 gcpy                  self.dxfsmV.close()
1662 gcpy              if (self.DT_tool_num > 0):
1663 gcpy                  self.dxfDT.close()
1664 gcpy              if (self.KH_tool_num > 0):
1665 gcpy                  self.dxfKH.close()
1666 gcpy              if (self.Roundover_tool_num > 0):
1667 gcpy                  self.dxfRt.close()
1668 gcpy              if (self.MISC_tool_num > 0):
1669 gcpy                  self.dxfMt.close()
```

closecodefile The commands: closecodefile, and closedxfile are used to close the files at the end of a
closedxfile program. For efficiency, each references the command: dxfpostamble which when called provides
dxfpostamble the boilerplate needed at the end of their respective files.

```
162 gcpscad module closecodefile(){
163 gcpscad     gcp.closecodefile();
164 gcpscad }
165 gcpscad
166 gcpscad module closedxfiles(){
167 gcpscad     gcp.closedxfiles();
168 gcpscad }
169 gcpscad
170 gcpscad module closedxfile(){
171 gcpscad     gcp.closedxfile();
172 gcpscad }
```

3.7 Cutting shapes and expansion

Certain basic shapes (arcs, circles, rectangles), will be incorporated in the main code. Other shapes will be added as they are developed, and of course the user is free to develop their own systems. It is most expedient to test out new features in a new/separate file insofar as the file structures will allow (tool definitions for example will need to be consolidated in 3.3.1.1) which will need to be included in the projects which will make use of said features until such time as they are added into the main gcodepreview.scad file.

A basic requirement for two-dimensional regions will be to define them so as to cut them out. Two different geometric treatments will be necessary: modeling the geometry which defines the region to be cut out (output as a DXF); and modeling the movement of the tool, the toolpath which will be used in creating the 3D model and outputting the G-code.

3.7.0.1 Building blocks The outlines of shapes will be defined using:

- lines — `dxfline`
- arcs — `dxfarc`

It may be that splines or Bézier curves will be added as well.

3.7.0.2 List of shapes In the TUG presentation/paper: <http://tug.org/TUGboat/tb40-2/tb125adams-3d.pdf> a list of 2D shapes was put forward — which of these will need to be created, or if some more general solution will be put forward is uncertain. For the time being, shapes will be implemented on an as-needed basis, as modified by the interaction with the requirements of toolpaths. Shapes for which code exists (or is trivially coded) are indicated by **Forest Green** — for those which have sub-classes, if all are feasible only the higher level is so called out.

- 0
 - **circle** — `dxfcircle`
 - ellipse (oval) (requires some sort of non-arc curve)
 - * egg-shaped
 - **annulus** (one circle within another, forming a ring) — handled by nested circles
 - superellipse (see astroid below)
- 1
 - **cone with rounded end (arc)**—see also “sector” under 3 below
- 2
 - **semicircle/circular/half-circle segment** (arc and a straight line); see also sector below
 - arch—curve possibly smoothly joining a pair of straight lines with a flat bottom
 - lens/vesica piscis (two convex curves)
 - lune/crescent (one convex, one concave curve)
 - heart (two curves)
 - tomoe (comma shape)—non-arc curves
- 3
 - **triangle**
 - * equilateral
 - * isosceles
 - * right triangle
 - * scalene
 - **(circular) sector** (two straight edges, one convex arc)
 - * quadrant (90°)
 - * sextants (60°)
 - * octants (45°)
 - deltoid curve (three concave arcs)
 - Reuleaux triangle (three convex arcs)
 - arbelos (one convex, two concave arcs)
 - two straight edges, one concave arc—an example is the hyperbolic sector¹
 - two convex, one concave arc
- 4
 - **rectangle (including square)** — `dxfrectangle`, `dxfrectangleround`
 - **parallelogram**
 - **rhombus**
 - **trapezoid/trapezium**
 - **kite**
 - **ring/annulus segment** (straight line, concave arc, straight line, convex arc)

¹en.wikipedia.org/wiki/Hyperbolic_sector and www.reddit.com/r/Geometry/comments/bkbzgh/is_there_a_name_for_a_3_pointed_figure_with_two

- astroid (four concave arcs)
- salinon (four semicircles)
- three straight lines and one concave arc

Note that most shapes will also exist in a rounded form where sharp angles/points are replaced by arcs/portions of circles, with the most typical being `dxfrectangleround`.
Is the list of shapes for which there are not widely known names interesting for its lack of notoriety?

- two straight edges, one concave arc—oddly, an asymmetric form (hyperbolic sector) has a name, but not the symmetrical—while the colloquial/prosaic “arrowhead” was considered, it was rejected as being better applied to the shape below. (It’s also the shape used for the spaceship in the game Asteroids (or Hyperspace), but that is potentially confusing with astroid.) At the conference, Dr. Knuth suggested “dart” as a suitable term.
- two convex, one concave arc—with the above named, the term “arrowhead” is freed up to use as the name for this shape.
- three straight lines and one concave arc.

The first in particular is sorely needed for this project (it’s the result of inscribing a circle in a square or other regular geometric shape). Do these shapes have names in any other languages which might be used instead?
These shapes will then be used in constructing toolpaths. The program Carbide Create has toolpath types and options which are as follows:

- Contour — No Offset — the default, this is already supported in the existing code
- Contour — Outside Offset
- Contour — Inside Offset
- Pocket — such toolpaths/geometry should include the rounding of the tool at the corners, c.f., `dxfrectangleround`
- Drill — note that this is implemented as the plunging of a tool centered on a circle and normally that circle is the same diameter as the tool which is used.
- Keyhole — also beginning from a circle, the command for this also models the areas which should be cleared for the sake of reducing wear on the tool and ensuring chip clearance

Some further considerations:

- relationship of geometry to toolpath — arguably there should be an option for each toolpath (we will use Carbide Create as a reference implementation) which is to be supported. Note that there are several possibilities: modeling the tool movement, describing the outline which the tool will cut, modeling a reference shape for the toolpath
- tool geometry — support is included for specialty tooling such as dovetail cutters allowing one to to get an accurate 3D model, including for tooling which undercuts since they cannot be modeled in Carbide Create.
- Starting and Max Depth — are there CAD programs which will make use of Z-axis information in a DXF? — would it be possible/necessary to further differentiate the DXF geometry? (currently written out separately for each toolpath in addition to one combined file) — would supporting layers be an option?

3.7.0.2.1 circles Circles are made up of a series of arcs:

```
1671 gcpy      def dxfcircle(self, tool_num, xcenter, ycenter, radius):
1672 gcpy          self.dxfarc(tool_num, xcenter, ycenter, radius, 0, 90)
1673 gcpy          self.dxfarc(tool_num, xcenter, ycenter, radius, 90, 180)
1674 gcpy          self.dxfarc(tool_num, xcenter, ycenter, radius, 180, 270)
1675 gcpy          self.dxfarc(tool_num, xcenter, ycenter, radius, 270, 360)
```

Actually cutting the circle is much the same, with the added consideration of entry point if Z height is not above the surface of the stock/already removed material, directionality (counter-clockwise vs. clockwise), and depth (beginning and end depths must be specified which should allow usage of this for thread-cutting and similar purposes).
Center is specified, but the actual entry point is the right-most edge.

```
1677 gcpy      def cutcircleCC(self, xcenter, ycenter, bz, ez, radius):
1678 gcpy          self.setzpos(bz)
1679 gcpy          self.cutquarterCCNE(xcenter, ycenter + radius, self.zpos()
                                     + ez/4, radius)
```

```
1680 gcpy          self.cutquarterCCNW(xcenter - radius, ycenter, self.zpos()
                    + ez/4, radius)
1681 gcpy          self.cutquarterCCSW(xcenter, ycenter - radius, self.zpos()
                    + ez/4, radius)
1682 gcpy          self.cutquarterCCSE(xcenter + radius, ycenter, self.zpos()
                    + ez/4, radius)
1683 gcpy
1684 gcpy          def cutcircleCCdx(self, xcenter, ycenter, bz, ez, radius):
1685 gcpy              self.cutcircleCC(self, xcenter, ycenter, bz, ez, radius)
1686 gcpy              self.dxfcircle(self, tool_num, xcenter, ycenter, radius)
```

A Drill toolpath is a simple plunge operation which will have a matching circle to define it.

3.7.0.2.2 rectangles There are two obvious forms for rectangles, square cornered and rounded:

```
1688 gcpy          def dxfrectangle(self, tool_num, xorigin, yorigin, xwidth,
                    yheight, corners = "Square", radius = 6):
1689 gcpy              if corners == "Square":
1690 gcpy                  self.dxfline(tool_num, xorigin, yorigin, xorigin +
                    xwidth, yorigin)
1691 gcpy                  self.dxfline(tool_num, xorigin + xwidth, yorigin,
                    xorigin + xwidth, yorigin + yheight)
1692 gcpy                  self.dxfline(tool_num, xorigin + xwidth, yorigin +
                    yheight, xorigin, yorigin + yheight)
1693 gcpy                  self.dxfline(tool_num, xorigin, yorigin + yheight,
                    xorigin, yorigin)
1694 gcpy              elif corners == "Fillet":
1695 gcpy                  self.dxfrectangleround(tool_num, xorigin, yorigin,
                    xwidth, yheight, radius)
1696 gcpy              elif corners == "Chamfer":
1697 gcpy                  self.dxfrectanglechamfer(tool_num, xorigin, yorigin,
                    xwidth, yheight, radius)
1698 gcpy              elif corners == "Flipped_Fillet":
1699 gcpy                  self.dxfrectangleflippedfillet(tool_num, xorigin,
                    yorigin, xwidth, yheight, radius)
```

Note that the rounded shape below would be described as a rectangle with the “Fillet” corner treatment in Carbide Create.

```
1701 gcpy          def dxfrectangleround(self, tool_num, xorigin, yorigin, xwidth,
                    yheight, radius):
1702 gcpy # begin section
1703 gcpy          self.writedxf(tool_num, "0")
1704 gcpy          self.writedxf(tool_num, "SECTION")
1705 gcpy          self.writedxf(tool_num, "2")
1706 gcpy          self.writedxf(tool_num, "ENTITIES")
1707 gcpy          self.writedxf(tool_num, "0")
1708 gcpy          self.writedxf(tool_num, "LWPOLYLINE")
1709 gcpy          self.writedxf(tool_num, "5")
1710 gcpy          self.writedxf(tool_num, "4E")
1711 gcpy          self.writedxf(tool_num, "100")
1712 gcpy          self.writedxf(tool_num, "AcDbEntity")
1713 gcpy          self.writedxf(tool_num, "8")
1714 gcpy          self.writedxf(tool_num, "0")
1715 gcpy          self.writedxf(tool_num, "6")
1716 gcpy          self.writedxf(tool_num, "ByLayer")
1717 gcpy #
1718 gcpy          self.writedxfcolor(tool_num)
1719 gcpy #
1720 gcpy          self.writedxf(tool_num, "370")
1721 gcpy          self.writedxf(tool_num, "-1")
1722 gcpy          self.writedxf(tool_num, "100")
1723 gcpy          self.writedxf(tool_num, "AcDbPolyline")
1724 gcpy          self.writedxf(tool_num, "90")
1725 gcpy          self.writedxf(tool_num, "8")
1726 gcpy          self.writedxf(tool_num, "70")
1727 gcpy          self.writedxf(tool_num, "1")
1728 gcpy          self.writedxf(tool_num, "43")
1729 gcpy          self.writedxf(tool_num, "0")
1730 gcpy #1 upper right corner before arc (counter-clockwise)
1731 gcpy          self.writedxf(tool_num, "10")
1732 gcpy          self.writedxf(tool_num, str(xorigin + xwidth))
1733 gcpy          self.writedxf(tool_num, "20")
1734 gcpy          self.writedxf(tool_num, str(yorigin + yheight - radius))
1735 gcpy          self.writedxf(tool_num, "42")
1736 gcpy          self.writedxf(tool_num, "0.414213562373095")
```

```
1737 gcpy #2 upper right corner after arc
1738 gcpy         self.writedxf(tool_num, "10")
1739 gcpy         self.writedxf(tool_num, str(xorigin + xwidth - radius))
1740 gcpy         self.writedxf(tool_num, "20")
1741 gcpy         self.writedxf(tool_num, str(yorigin + yheight))
1742 gcpy #3 upper left corner before arc (counter-clockwise)
1743 gcpy         self.writedxf(tool_num, "10")
1744 gcpy         self.writedxf(tool_num, str(xorigin + radius))
1745 gcpy         self.writedxf(tool_num, "20")
1746 gcpy         self.writedxf(tool_num, str(yorigin + yheight))
1747 gcpy         self.writedxf(tool_num, "42")
1748 gcpy         self.writedxf(tool_num, "0.414213562373095")
1749 gcpy #4 upper left corner after arc
1750 gcpy         self.writedxf(tool_num, "10")
1751 gcpy         self.writedxf(tool_num, str(xorigin))
1752 gcpy         self.writedxf(tool_num, "20")
1753 gcpy         self.writedxf(tool_num, str(yorigin + yheight - radius))
1754 gcpy #5 lower left corner before arc (counter-clockwise)
1755 gcpy         self.writedxf(tool_num, "10")
1756 gcpy         self.writedxf(tool_num, str(xorigin))
1757 gcpy         self.writedxf(tool_num, "20")
1758 gcpy         self.writedxf(tool_num, str(yorigin + radius))
1759 gcpy         self.writedxf(tool_num, "42")
1760 gcpy         self.writedxf(tool_num, "0.414213562373095")
1761 gcpy #6 lower left corner after arc
1762 gcpy         self.writedxf(tool_num, "10")
1763 gcpy         self.writedxf(tool_num, str(xorigin + radius))
1764 gcpy         self.writedxf(tool_num, "20")
1765 gcpy         self.writedxf(tool_num, str(yorigin))
1766 gcpy #7 lower right corner before arc (counter-clockwise)
1767 gcpy         self.writedxf(tool_num, "10")
1768 gcpy         self.writedxf(tool_num, str(xorigin + xwidth - radius))
1769 gcpy         self.writedxf(tool_num, "20")
1770 gcpy         self.writedxf(tool_num, str(yorigin))
1771 gcpy         self.writedxf(tool_num, "42")
1772 gcpy         self.writedxf(tool_num, "0.414213562373095")
1773 gcpy #8 lower right corner after arc
1774 gcpy         self.writedxf(tool_num, "10")
1775 gcpy         self.writedxf(tool_num, str(xorigin + xwidth))
1776 gcpy         self.writedxf(tool_num, "20")
1777 gcpy         self.writedxf(tool_num, str(yorigin + radius))
1778 gcpy # end current section
1779 gcpy         self.writedxf(tool_num, "0")
1780 gcpy         self.writedxf(tool_num, "SEQEND")
```

So we add the balance of the corner treatments which are decorative (and easily implemented).
Chamfer:

```
1782 gcpy         def dxfrectanglechamfer(self, tool_num, xorigin, yorigin,
1783 gcpy             xwidth, yheight, radius):
1784 gcpy             self.dxfline(tool_num, xorigin + radius, yorigin, xorigin,
1785 gcpy                 yorigin + radius)
1786 gcpy             self.dxfline(tool_num, xorigin, yorigin + yheight - radius,
1787 gcpy                 xorigin + radius, yorigin + yheight)
1788 gcpy             self.dxfline(tool_num, xorigin + xwidth - radius, yorigin +
1789 gcpy                 yheight, xorigin + xwidth, yorigin + yheight - radius)
1790 gcpy             self.dxfline(tool_num, xorigin + xwidth - radius, yorigin,
1791 gcpy                 xorigin + xwidth, yorigin + radius)
```

Flipped Fillet:

```
1793 gcpy         def dxfrectangleflippedfillet(self, tool_num, xorigin, yorigin,
1794 gcpy             xwidth, yheight, radius):
1795 gcpy             self.dxfarc(tool_num, xorigin, yorigin, radius, 0, 90)
1796 gcpy             self.dxfarc(tool_num, xorigin + xwidth, yorigin, radius,
1797 gcpy                 90, 180)
1798 gcpy             self.dxfarc(tool_num, xorigin + xwidth, yorigin + yheight,
1799 gcpy                 radius, 180, 270)
```

```
1797 gcpy          self.dxfarc(tool_num, xorigin, yorigin + yheight, radius,
                             270, 360)
1798 gcpy
1799 gcpy          self.dxfline(tool_num, xorigin + radius, yorigin, xorigin +
                             xwidth - radius, yorigin)
1800 gcpy          self.dxfline(tool_num, xorigin + xwidth, yorigin + radius,
                             xorigin + xwidth, yorigin + yheight - radius)
1801 gcpy          self.dxfline(tool_num, xorigin + xwidth - radius, yorigin +
                             yheight, xorigin + radius, yorigin + yheight)
1802 gcpy          self.dxfline(tool_num, xorigin, yorigin + yheight - radius,
                             xorigin, yorigin + radius)
```

Cutting rectangles while writing out their perimeter in the DXF files (so that they may be assigned a matching toolpath in a traditional CAM program upon import) will require the origin coordinates, height and width and depth of the pocket, and the tool # so that the corners may have a radius equal to the tool which is used. Whether a given module is an interior pocket or an outline (interior or exterior) will be determined by the specifics of the module and its usage/positioning, with outline being added to those modules which cut perimeter.

A further consideration is that cut orientation as an option should be accounted for if writing out G-code, as well as stepover, and the nature of initial entry (whether ramping in would be implemented, and if so, at what angle). Advanced toolpath strategies such as trochoidal milling could also be implemented.

cutrectangle The routine cutrectangle cuts the outline of a rectangle creating rounded corners.

```
1804 gcpy          def cutrectangle(self, tool_num, bx, by, bz, xwidth, yheight,
                             zdepth):
1805 gcpy              self.cutline(bx, by, bz)
1806 gcpy              self.cutline(bx, by, bz - zdepth)
1807 gcpy              self.cutline(bx + xwidth, by, bz - zdepth)
1808 gcpy              self.cutline(bx + xwidth, by + yheight, bz - zdepth)
1809 gcpy              self.cutline(bx, by + yheight, bz - zdepth)
1810 gcpy              self.cutline(bx, by, bz - zdepth)
1811 gcpy
1812 gcpy          def cutrectangledxf(self, tool_num, bx, by, bz, xwidth, yheight
                             , zdepth):
1813 gcpy              self.cutrectangle(tool_num, bx, by, bz, xwidth, yheight,
                             zdepth)
1814 gcpy              self.dxfrectangle(tool_num, bx, by, xwidth, yheight, "
                             Square")
```

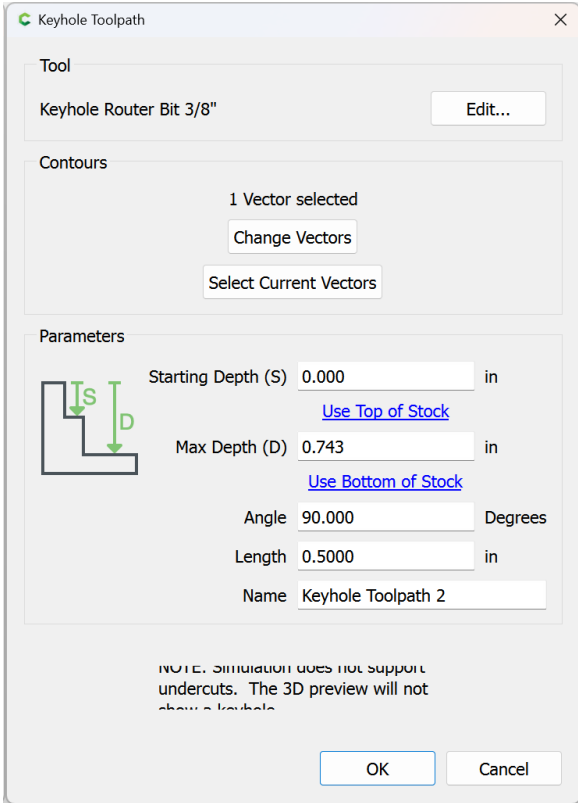
The rounded forms instantiate a radius:

```
1816 gcpy          def cutrectangleround(self, tool_num, bx, by, bz, xwidth,
                             yheight, zdepth, radius):
1817 gcpy #              self.rapid(bx + radius, by, bz)
1818 gcpy              self.cutline(bx + radius, by, bz + zdepth)
1819 gcpy              self.cutline(bx + xwidth - radius, by, bz + zdepth)
1820 gcpy              self.cutquarterCCSE(bx + xwidth, by + radius, bz + zdepth,
                             radius)
1821 gcpy              self.cutline(bx + xwidth, by + yheight - radius, bz +
                             zdepth)
1822 gcpy              self.cutquarterCCNE(bx + xwidth - radius, by + yheight, bz
                             + zdepth, radius)
1823 gcpy              self.cutline(bx + radius, by + yheight, bz + zdepth)
1824 gcpy              self.cutquarterCCNW(bx, by + yheight - radius, bz + zdepth,
                             radius)
1825 gcpy              self.cutline(bx, by + radius, bz + zdepth)
1826 gcpy              self.cutquarterCCSW(bx + radius, by, bz + zdepth, radius)
1827 gcpy
1828 gcpy          def cutrectanglerounddxf(self, tool_num, bx, by, bz, xwidth,
                             yheight, zdepth, radius):
1829 gcpy              self.cutrectangleround(tool_num, bx, by, bz, xwidth,
                             yheight, zdepth, radius)
1830 gcpy              self.dxfrectangleround(tool_num, bx, by, xwidth, yheight,
                             radius)
```

cutkeyhole toolpath **3.7.0.2.3 Keyhole toolpath and undercut tooling** The first topologically unusual toolpath is cutkeyhole toolpath — where other toolpaths have a direct correspondence between the associated geometry and the area cut, that Keyhole toolpaths may be used with tooling which undercuts and which will result in the creation of two different physical physical regions: the visible surface matching the union of the tool perimeter at the entry point and the linear movement of the shaft and the larger region of the tool perimeter at the depth which the tool is plunged to and moved along.

Tooling for such toolpaths is defined at paragraph 3.4.0.1

The interface which is being modeled is that of Carbide Create:



Hence the parameters:

- Starting Depth == kh_start_depth
- Max Depth == kh_max_depth
- Angle == kht_direction
- Length == kh_distance
- Tool == kh_tool_num

Due to the possibility of rotation, for the in-between positions there are more cases than one would think — for each quadrant there are the following possibilities:

- one node on the clockwise side is outside of the quadrant
- two nodes on the clockwise side are outside of the quadrant
- all nodes are w/in the quadrant
- one node on the counter-clockwise side is outside of the quadrant
- two nodes on the counter-clockwise side are outside of the quadrant

Supporting all of these would require trigonometric comparisons in the `if...else` blocks, so only the 4 quadrants, N, S, E, and W will be supported in the initial version. This will be done by wrapping the command with a version which only accepts those options:

```
1832 gcpy      def cutkeyholegdcxf(self, kh_tool_num, kh_start_depth,
1833 gcpy          kh_max_depth, kht_direction, kh_distance):
1834 gcpy          toolpath = self.cutKHgdcxf(kh_tool_num, kh_start_depth,
1835 gcpy              kh_max_depth, 90, kh_distance)
1836 gcpy          elif (kht_direction == "S"):
1837 gcpy              toolpath = self.cutKHgdcxf(kh_tool_num, kh_start_depth,
1838 gcpy                  kh_max_depth, 270, kh_distance)
1839 gcpy          elif (kht_direction == "E"):
1840 gcpy              toolpath = self.cutKHgdcxf(kh_tool_num, kh_start_depth,
1841 gcpy                  kh_max_depth, 0, kh_distance)
1842 gcpy          elif (kht_direction == "W"):
1843 gcpy              toolpath = self.cutKHgdcxf(kh_tool_num, kh_start_depth,
1844 gcpy                  kh_max_depth, 180, kh_distance)
1845 gcpy          if self.generatepaths == True:
1846 gcpy              self.toolpaths = union([self.toolpaths, toolpath])
1847 gcpy          return toolpath
1848 gcpy          else:
1849 gcpy              return cube([0.01, 0.01, 0.01])
```

```
174 gcpscad module cutkeyholegcdxf(kh_tool_num, kh_start_depth, kh_max_depth,
    kht_direction, kh_distance){
175 gcpscad     gcp.cutkeyholegcdxf(kh_tool_num, kh_start_depth, kh_max_depth,
        kht_direction, kh_distance);
176 gcpscad }
```

cutKHgcdxf The original version of the command, cutKHgcdxf retains an interface which allows calling it for arbitrary beginning and ending points of an arc.

Note that code is still present for the partial calculation of one quadrant (for the case of all nodes within the quadrant). The first task is to place a circle at the origin which is invariant of angle:

```
1847 gcpy      def cutKHgcdxf(self, kh_tool_num, kh_start_depth, kh_max_depth,
    kh_angle, kh_distance):
1848 gcpy        oXpos = self.xpos()
1849 gcpy        oYpos = self.ypos()
1850 gcpy        self.dxfKH(kh_tool_num, self.xpos(), self.ypos(),
    kh_start_depth, kh_max_depth, kh_angle, kh_distance)
1851 gcpy        toolpath = self.cutline(self.xpos(), self.ypos(), -
    kh_max_depth)
1852 gcpy        self.setxpos(oXpos)
1853 gcpy        self.setypos(oYpos)
1854 gcpy #      if self.generatepaths == False:
1855 gcpy      return toolpath
1856 gcpy #      else:
1857 gcpy #      return cube([0.001, 0.001, 0.001])

1859 gcpy      def dxfKH(self, kh_tool_num, oXpos, oYpos, kh_start_depth,
    kh_max_depth, kh_angle, kh_distance):
1860 gcpy #      oXpos = self.xpos()
1861 gcpy #      oYpos = self.ypos()
1862 gcpy #Circle at entry hole
1863 gcpy      self.dxfarc(kh_tool_num, oXpos, oYpos, self.tool_radius(
    kh_tool_num, 7), 0, 90)
1864 gcpy      self.dxfarc(kh_tool_num, oXpos, oYpos, self.tool_radius(
    kh_tool_num, 7), 90, 180)
1865 gcpy      self.dxfarc(kh_tool_num, oXpos, oYpos, self.tool_radius(
    kh_tool_num, 7), 180, 270)
1866 gcpy      self.dxfarc(kh_tool_num, oXpos, oYpos, self.tool_radius(
    kh_tool_num, 7), 270, 360)
```

Then it will be necessary to test for each possible case in a series of If Else blocks:

```
1867 gcpy #pre-calculate needed values
1868 gcpy      r = self.tool_radius(kh_tool_num, 7)
1869 gcpy #      print(r)
1870 gcpy      rt = self.tool_radius(kh_tool_num, 1)
1871 gcpy #      print(rt)
1872 gcpy      ro = math.sqrt((self.tool_radius(kh_tool_num, 1))**2-(self.
    tool_radius(kh_tool_num, 7))**2)
1873 gcpy #      print(ro)
1874 gcpy      angle = math.degrees(math.acos(ro/rt))
1875 gcpy #Outlines of entry hole and slot
1876 gcpy      if (kh_angle == 0):
1877 gcpy #Lower left of entry hole
1878 gcpy          self.dxfarc(kh_tool_num, self.xpos(), self.ypos(), self
    .tool_radius(kh_tool_num, 1), 180, 270)
1879 gcpy #Upper left of entry hole
1880 gcpy          self.dxfarc(kh_tool_num, self.xpos(), self.ypos(), self
    .tool_radius(kh_tool_num, 1), 90, 180)
1881 gcpy #Upper right of entry hole
1882 gcpy #      self.dxfarc(kh_tool_num, self.xpos(), self.ypos(), rt,
    41.810, 90)
1883 gcpy          self.dxfarc(kh_tool_num, self.xpos(), self.ypos(), rt,
    angle, 90)
1884 gcpy #Lower right of entry hole
1885 gcpy          self.dxfarc(kh_tool_num, self.xpos(), self.ypos(), rt,
    270, 360-angle)
1886 gcpy #      self.dxfarc(kh_tool_num, self.xpos(), self.ypos(),
    self.tool_radius(kh_tool_num, 1), 270, 270+math.acos(math.
    radians(self.tool_diameter(kh_tool_num, 5)/self.tool_diameter(
    kh_tool_num, 1)))
1887 gcpy #Actual line of cut
1888 gcpy #      self.dxfline(kh_tool_num, self.xpos(), self.ypos(),
    self.xpos()+kh_distance, self.ypos())
```

```

1889 gcpy #upper right of end of slot (kh_max_depth+4.36))/2
1890 gcpy          self.dxfarc(kh_tool_num, self.xpos()+kh_distance, self.
                        ypos(), self.tool_diameter(kh_tool_num, (
                        kh_max_depth+4.36))/2, 0, 90)
1891 gcpy #lower right of end of slot
1892 gcpy          self.dxfarc(kh_tool_num, self.xpos()+kh_distance, self.
                        ypos(), self.tool_diameter(kh_tool_num, (
                        kh_max_depth+4.36))/2, 270, 360)
1893 gcpy #upper right slot
1894 gcpy          self.dxfline(kh_tool_num, self.xpos()+ro, self.ypos()-(
                        self.tool_diameter(kh_tool_num, 7)/2), self.xpos()+
                        kh_distance, self.ypos()-(self.tool_diameter(
                        kh_tool_num, 7)/2))
1895 gcpy #          self.dxfline(kh_tool_num, self.xpos()+(math.sqrt((self
                        .tool_diameter(kh_tool_num, 1)^2)-(self.tool_diameter(
                        kh_tool_num, 5)^2))/2), self.ypos()+self.tool_diameter(
                        kh_tool_num, (kh_max_depth))/2, ((kh_max_depth-6.34))/2)^2-(
                        self.tool_diameter(kh_tool_num, (kh_max_depth-6.34))/2)^2, self.
                        xpos()+kh_distance, self.ypos()+self.tool_diameter(kh_tool_num,
                        (kh_max_depth))/2, kh_tool_num)
1896 gcpy #end position at top of slot
1897 gcpy #lower right slot
1898 gcpy          self.dxfline(kh_tool_num, self.xpos()+ro, self.ypos()+(
                        self.tool_diameter(kh_tool_num, 7)/2), self.xpos()+
                        kh_distance, self.ypos()+(self.tool_diameter(
                        kh_tool_num, 7)/2))
1899 gcpy #          dxfline(kh_tool_num, self.xpos()+(math.sqrt((self.
                        tool_diameter(kh_tool_num, 1)^2)-(self.tool_diameter(kh_tool_num
                        , 5)^2))/2), self.ypos()-self.tool_diameter(kh_tool_num, (
                        kh_max_depth))/2, ((kh_max_depth-6.34))/2)^2-(self.
                        tool_diameter(kh_tool_num, (kh_max_depth-6.34))/2)^2, self.xpos
                        ()+kh_distance, self.ypos()-self.tool_diameter(kh_tool_num, (
                        kh_max_depth))/2, KH_tool_num)
1900 gcpy #end position at top of slot
1901 gcpy #          hull(){
1902 gcpy #              translate([xpos(), ypos(), zpos()]){
1903 gcpy #                  keyhole_shaft(6.35, 9.525);
1904 gcpy #              }
1905 gcpy #              translate([xpos(), ypos(), zpos()-kh_max_depth]){
1906 gcpy #                  keyhole_shaft(6.35, 9.525);
1907 gcpy #              }
1908 gcpy #          }
1909 gcpy #          hull(){
1910 gcpy #              translate([xpos(), ypos(), zpos()-kh_max_depth]){
1911 gcpy #                  keyhole_shaft(6.35, 9.525);
1912 gcpy #              }
1913 gcpy #              translate([xpos()+kh_distance, ypos(), zpos()-kh_max_depth])
1914 gcpy #                  {
1915 gcpy #                      keyhole_shaft(6.35, 9.525);
1916 gcpy #                  }
1917 gcpy #              cutwithfeed(getxpos(), getypos(), -kh_max_depth, feed);
1918 gcpy #              cutwithfeed(getxpos()+kh_distance, getypos(), -kh_max_depth,
1919 gcpy #                  feed);
1919 gcpy #              setxpos(getxpos()-kh_distance);
1920 gcpy #          } else if (kh_angle > 0 && kh_angle < 90) {
1921 gcpy #              //echo(kh_angle);
1922 gcpy #              dxfarc(getxpos(), getypos(), tool_diameter(KH_tool_num, (
1923 gcpy #                  kh_max_depth))/2, 90+kh_angle, 180+kh_angle, KH_tool_num);
1923 gcpy #              dxfarc(getxpos(), getypos(), tool_diameter(KH_tool_num, (
1924 gcpy #                  kh_max_depth))/2, 180+kh_angle, 270+kh_angle, KH_tool_num);
1924 gcpy #              dxfarc(getxpos(), getypos(), tool_diameter(KH_tool_num, (
1925 gcpy #                  kh_max_depth+4.36))/2, kh_angle+asin((tool_diameter(KH_tool_num, (
1926 gcpy #                      kh_max_depth+4.36))/2)/(tool_diameter(KH_tool_num, (kh_max_depth
1927 gcpy #                      ))/2)), 90+kh_angle, KH_tool_num);
1925 gcpy #              dxfarc(getxpos(), getypos(), tool_diameter(KH_tool_num, (
1926 gcpy #                  kh_max_depth))/2, 270+kh_angle, 360+kh_angle-asin((tool_diameter
1927 gcpy #                      (KH_tool_num, (kh_max_depth+4.36))/2)/(tool_diameter(KH_tool_num
1928 gcpy #                      , (kh_max_depth))/2)), KH_tool_num);
1926 gcpy #              dxfarc(getxpos()+(kh_distance*cos(kh_angle)),
1927 gcpy #                  getypos()+(kh_distance*sin(kh_angle)), tool_diameter(KH_tool_num
1928 gcpy #                      , (kh_max_depth+4.36))/2, 0+kh_angle, 90+kh_angle, KH_tool_num);
1928 gcpy #              dxfarc(getxpos()+(kh_distance*cos(kh_angle)), getypos()+(
1929 gcpy #                  kh_distance*sin(kh_angle)), tool_diameter(KH_tool_num, (
1930 gcpy #                      kh_max_depth+4.36))/2, 270+kh_angle, 360+kh_angle, KH_tool_num);
1929 gcpy #              dxfline( getxpos()+tool_diameter(KH_tool_num, (kh_max_depth))/2*
1930 gcpy #                  cos(kh_angle+asin((tool_diameter(KH_tool_num, (kh_max_depth
1931 gcpy #                      +4.36))/2)/(tool_diameter(KH_tool_num, (kh_max_depth))/2))),

```



```

1930 gcpy # getypos()+tool_diameter(KH_tool_num, (kh_max_depth))/2*sin(
           kh_angle+asin((tool_diameter(KH_tool_num, (kh_max_depth+4.36))
           /2)/(tool_diameter(KH_tool_num, (kh_max_depth))/2))),
1931 gcpy # getxpos()+(kh_distance*cos(kh_angle))-((tool_diameter(KH_tool_num
           , (kh_max_depth+4.36))/2)*sin(kh_angle)),
1932 gcpy # getypos()+(kh_distance*sin(kh_angle))+((tool_diameter(KH_tool_num
           , (kh_max_depth+4.36))/2)*cos(kh_angle)), KH_tool_num);
1933 gcpy #//echo("a", tool_diameter(KH_tool_num, (kh_max_depth+4.36))/2);
1934 gcpy #//echo("c", tool_diameter(KH_tool_num, (kh_max_depth))/2);
1935 gcpy #echo("Aangle", asin((tool_diameter(KH_tool_num, (kh_max_depth
           +4.36))/2)/(tool_diameter(KH_tool_num, (kh_max_depth))/2)));
1936 gcpy #//echo(kh_angle);
1937 gcpy # cutwithfeed(getxpos()+(kh_distance*cos(kh_angle)), getypos()+(
           kh_distance*sin(kh_angle)), -kh_max_depth, feed);
1938 gcpy #           toolpath = toolpath.union(self.cutline(self.xpos()+
           kh_distance, self.ypos(), -kh_max_depth))
1939 gcpy           elif (kh_angle == 90):
1940 gcpy #Lower left of entry hole
1941 gcpy           self.dxfarc(kh_tool_num, oXpos, oYpos, self.tool_radius
           (kh_tool_num, 1), 180, 270)
1942 gcpy #Lower right of entry hole
1943 gcpy           self.dxfarc(kh_tool_num, oXpos, oYpos, self.tool_radius
           (kh_tool_num, 1), 270, 360)
1944 gcpy #left slot
1945 gcpy           self.dxfline(kh_tool_num, oXpos-r, oYpos+ro, oXpos-r,
           oYpos+kh_distance)
1946 gcpy #right slot
1947 gcpy           self.dxfline(kh_tool_num, oXpos+r, oYpos+ro, oXpos+r,
           oYpos+kh_distance)
1948 gcpy #upper left of end of slot
1949 gcpy           self.dxfarc(kh_tool_num, oXpos, oYpos+kh_distance, r,
           90, 180)
1950 gcpy #upper right of end of slot
1951 gcpy           self.dxfarc(kh_tool_num, oXpos, oYpos+kh_distance, r,
           0, 90)
1952 gcpy #Upper right of entry hole
1953 gcpy           self.dxfarc(kh_tool_num, oXpos, oYpos, rt, 0, 90-angle)
1954 gcpy #Upper left of entry hole
1955 gcpy           self.dxfarc(kh_tool_num, oXpos, oYpos, rt, 90+angle,
           180)
1956 gcpy #           toolpath = toolpath.union(self.cutline(oXpos, oYpos+
           kh_distance, -kh_max_depth))
1957 gcpy           elif (kh_angle == 180):
1958 gcpy #Lower right of entry hole
1959 gcpy           self.dxfarc(kh_tool_num, oXpos, oYpos, self.tool_radius
           (kh_tool_num, 1), 270, 360)
1960 gcpy #Upper right of entry hole
1961 gcpy           self.dxfarc(kh_tool_num, oXpos, oYpos, self.tool_radius
           (kh_tool_num, 1), 0, 90)
1962 gcpy #Upper left of entry hole
1963 gcpy           self.dxfarc(kh_tool_num, oXpos, oYpos, rt, 90, 180-
           angle)
1964 gcpy #Lower left of entry hole
1965 gcpy           self.dxfarc(kh_tool_num, oXpos, oYpos, rt, 180+angle,
           270)
1966 gcpy #upper slot
1967 gcpy           self.dxfline(kh_tool_num, oXpos-ro, oYpos-r, oXpos-
           kh_distance, oYpos-r)
1968 gcpy #lower slot
1969 gcpy           self.dxfline(kh_tool_num, oXpos-ro, oYpos+r, oXpos-
           kh_distance, oYpos+r)
1970 gcpy #upper left of end of slot
1971 gcpy           self.dxfarc(kh_tool_num, oXpos-kh_distance, oYpos, r,
           90, 180)
1972 gcpy #lower left of end of slot
1973 gcpy           self.dxfarc(kh_tool_num, oXpos-kh_distance, oYpos, r,
           180, 270)
1974 gcpy #           toolpath = toolpath.union(self.cutline(oXpos-
           kh_distance, oYpos, -kh_max_depth))
1975 gcpy           elif (kh_angle == 270):
1976 gcpy #Upper left of entry hole
1977 gcpy           self.dxfarc(kh_tool_num, oXpos, oYpos, self.tool_radius
           (kh_tool_num, 1), 90, 180)
1978 gcpy #Upper right of entry hole
1979 gcpy           self.dxfarc(kh_tool_num, oXpos, oYpos, self.tool_radius
           (kh_tool_num, 1), 0, 90)
1980 gcpy #left slot
1981 gcpy           self.dxfline(kh_tool_num, oXpos-r, oYpos-ro, oXpos-r,

```

```

                                oYpos-kh_distance)
1982 gcpy #right slot
1983 gcpy                                self.dxfline(kh_tool_num, oXpos+r, oYpos-ro, oXpos+r,
                                                oYpos-kh_distance)
1984 gcpy #lower left of end of slot
1985 gcpy                                self.dxfarc(kh_tool_num, oXpos, oYpos-kh_distance, r,
                                                180, 270)
1986 gcpy #lower right of end of slot
1987 gcpy                                self.dxfarc(kh_tool_num, oXpos, oYpos-kh_distance, r,
                                                270, 360)
1988 gcpy #lower right of entry hole
1989 gcpy                                self.dxfarc(kh_tool_num, oXpos, oYpos, rt, 180, 270-
                                                angle)
1990 gcpy #lower left of entry hole
1991 gcpy                                self.dxfarc(kh_tool_num, oXpos, oYpos, rt, 270+angle,
                                                360)
1992 gcpy #                                toolpath = toolpath.union(self.cutline(oXpos, oYpos-
kh_distance, -kh_max_depth))
1993 gcpy #                                print(self.zpos())
1994 gcpy #                                self.setxpos(oXpos)
1995 gcpy #                                self.setypos(oYpos)
1996 gcpy #                                if self.generatepaths == False:
1997 gcpy #                                    return toolpath
1998 gcpy
1999 gcpy # } else if (kh_angle == 90) {
2000 gcpy #     //Lower left of entry hole
2001 gcpy #     dxfarc(getxpos(), getypos(), 9.525/2, 180, 270, KH_tool_num);
2002 gcpy #     //Lower right of entry hole
2003 gcpy #     dxfarc(getxpos(), getypos(), 9.525/2, 270, 360, KH_tool_num);
2004 gcpy #     //Upper right of entry hole
2005 gcpy #     dxfarc(getxpos(), getypos(), 9.525/2, 0, acos(tool_diameter(
KH_tool_num, 5)/tool_diameter(KH_tool_num, 1)), KH_tool_num);
2006 gcpy #     //Upper left of entry hole
2007 gcpy #     dxfarc(getxpos(), getypos(), 9.525/2, 180-acos(tool_diameter(
KH_tool_num, 5)/tool_diameter(KH_tool_num, 1)), 180, KH_tool_num
);
2008 gcpy #     //Actual line of cut
2009 gcpy #     dxfline(getxpos(), getypos(), getxpos(), getypos()+kh_distance
);
2010 gcpy #     //upper right of slot
2011 gcpy #     dxfarc(getxpos(), getypos()+kh_distance, tool_diameter(
KH_tool_num, (kh_max_depth+4.36))/2, 0, 90, KH_tool_num);
2012 gcpy #     //upper left of slot
2013 gcpy #     dxfarc(getxpos(), getypos()+kh_distance, tool_diameter(
KH_tool_num, (kh_max_depth+6.35))/2, 90, 180, KH_tool_num);
2014 gcpy #     //right of slot
2015 gcpy #     dxfline(
2016 gcpy #         getxpos()+tool_diameter(KH_tool_num, (kh_max_depth))/2,
2017 gcpy #         getypos()+(math.sqrt((tool_diameter(KH_tool_num, 1)^2)-(
tool_diameter(KH_tool_num, 5)^2))/2), //( kh_max_depth-6.34))
/2)^2-(tool_diameter(KH_tool_num, (kh_max_depth-6.34))/2)^2,
2018 gcpy #         getxpos()+tool_diameter(KH_tool_num, (kh_max_depth))/2,
2019 gcpy #         //end position at top of slot
2020 gcpy #         getypos()+kh_distance,
2021 gcpy #         KH_tool_num);
2022 gcpy #     dxfline(getxpos()-tool_diameter(KH_tool_num, (kh_max_depth))
/2, getypos()+(math.sqrt((tool_diameter(KH_tool_num, 1)^2)-(
tool_diameter(KH_tool_num, 5)^2))/2), getxpos()-tool_diameter(
KH_tool_num, (kh_max_depth+6.35))/2, getypos()+kh_distance,
KH_tool_num);
2023 gcpy #     hull(){
2024 gcpy #         translate([xpos(), ypos(), zpos()]){
2025 gcpy #             keyhole_shaft(6.35, 9.525);
2026 gcpy #         }
2027 gcpy #         translate([xpos(), ypos(), zpos()-kh_max_depth]){
2028 gcpy #             keyhole_shaft(6.35, 9.525);
2029 gcpy #         }
2030 gcpy #     }
2031 gcpy #     hull(){
2032 gcpy #         translate([xpos(), ypos(), zpos()-kh_max_depth]){
2033 gcpy #             keyhole_shaft(6.35, 9.525);
2034 gcpy #         }
2035 gcpy #         translate([xpos(), ypos()+kh_distance, zpos()-kh_max_depth])
{
2036 gcpy #             keyhole_shaft(6.35, 9.525);
2037 gcpy #         }
2038 gcpy #     }
2039 gcpy #     cutwithfeed(getxpos(), getypos(), -kh_max_depth, feed);

```

```

2040 gcpy #      cutwithfeed(getxpos(), getypos()+kh_distance, -kh_max_depth,
                feed);
2041 gcpy #      setypos(getypos()-kh_distance);
2042 gcpy # } else if (kh_angle == 180) {
2043 gcpy #      //Lower right of entry hole
2044 gcpy #      dxfarc(getxpos(), getypos(), 9.525/2, 270, 360, KH_tool_num);
2045 gcpy #      //Upper right of entry hole
2046 gcpy #      dxfarc(getxpos(), getypos(), 9.525/2, 0, 90, KH_tool_num);
2047 gcpy #      //Upper left of entry hole
2048 gcpy #      dxfarc(getxpos(), getypos(), 9.525/2, 90, 90+acos(
                tool_diameter(KH_tool_num, 5)/tool_diameter(KH_tool_num, 1)),
                KH_tool_num);
2049 gcpy #      //Lower left of entry hole
2050 gcpy #      dxfarc(getxpos(), getypos(), 9.525/2, 270-acos(tool_diameter(
                KH_tool_num, 5)/tool_diameter(KH_tool_num, 1)), 270, KH_tool_num
                );
2051 gcpy #      //upper left of slot
2052 gcpy #      dxfarc(getxpos()-kh_distance, getypos(), tool_diameter(
                KH_tool_num, (kh_max_depth+6.35))/2, 90, 180, KH_tool_num);
2053 gcpy #      //lower left of slot
2054 gcpy #      dxfarc(getxpos()-kh_distance, getypos(), tool_diameter(
                KH_tool_num, (kh_max_depth+6.35))/2, 180, 270, KH_tool_num);
2055 gcpy #      //Actual line of cut
2056 gcpy #      dxfline(getxpos(), getypos(), getxpos()-kh_distance, getypos()
                );
2057 gcpy #      //upper left slot
2058 gcpy #      dxfline(
2059 gcpy #          getxpos()-(math.sqrt((tool_diameter(KH_tool_num, 1)^2)-(
                tool_diameter(KH_tool_num, 5)^2))/2),
2060 gcpy #          getypos()+tool_diameter(KH_tool_num, (kh_max_depth))/2,
                //( (kh_max_depth-6.34))/2)^2-(tool_diameter(KH_tool_num, (
                kh_max_depth-6.34))/2)^2,
                getxpos()-kh_distance,
2061 gcpy #          //end position at top of slot
2062 gcpy #          getypos()+tool_diameter(KH_tool_num, (kh_max_depth))/2,
                KH_tool_num);
2063 gcpy #          //lower right slot
2064 gcpy #          dxfline(
2065 gcpy #              getxpos()-(math.sqrt((tool_diameter(KH_tool_num, 1)^2)-(
                tool_diameter(KH_tool_num, 5)^2))/2),
2066 gcpy #              getypos()-tool_diameter(KH_tool_num, (kh_max_depth))/2,
                //( (kh_max_depth-6.34))/2)^2-(tool_diameter(KH_tool_num, (
                kh_max_depth-6.34))/2)^2,
                getxpos()-kh_distance,
2067 gcpy #          //end position at top of slot
2068 gcpy #          getypos()-tool_diameter(KH_tool_num, (kh_max_depth))/2,
                KH_tool_num);
2069 gcpy #      hull(){
2070 gcpy #          translate([xpos(), ypos(), zpos()]){
2071 gcpy #              keyhole_shaft(6.35, 9.525);
2072 gcpy #          }
2073 gcpy #          translate([xpos(), ypos(), zpos()-kh_max_depth]){
2074 gcpy #              keyhole_shaft(6.35, 9.525);
2075 gcpy #          }
2076 gcpy #      }
2077 gcpy #      hull(){
2078 gcpy #          translate([xpos(), ypos(), zpos()-kh_max_depth]){
2079 gcpy #              keyhole_shaft(6.35, 9.525);
2080 gcpy #          }
2081 gcpy #          translate([xpos()-kh_distance, ypos(), zpos()-kh_max_depth])
                {
2082 gcpy #              keyhole_shaft(6.35, 9.525);
2083 gcpy #          }
2084 gcpy #      }
2085 gcpy #      cutwithfeed(getxpos(), getypos(), -kh_max_depth, feed);
2086 gcpy #      cutwithfeed(getxpos()-kh_distance, getypos(), -kh_max_depth,
                feed);
2087 gcpy #      setxpos(getxpos()+kh_distance);
2088 gcpy # } else if (kh_angle == 270) {
2089 gcpy #      //Upper right of entry hole
2090 gcpy #      dxfarc(getxpos(), getypos(), 9.525/2, 0, 90, KH_tool_num);
2091 gcpy #      //Upper left of entry hole
2092 gcpy #      dxfarc(getxpos(), getypos(), 9.525/2, 90, 180, KH_tool_num);
2093 gcpy #      //lower right of slot
2094 gcpy #      dxfarc(getxpos(), getypos()-kh_distance, tool_diameter(
                KH_tool_num, (kh_max_depth+4.36))/2, 270, 360, KH_tool_num);
2095 gcpy #      //lower left of slot
2096 gcpy #      dxfarc(getxpos(), getypos()-kh_distance, tool_diameter(

```

```

KH_tool_num, (kh_max_depth+4.36))/2, 180, 270, KH_tool_num);
2101 gcpy # //Actual line of cut
2102 gcpy # dxfline(getxpos(), getypos(), getxpos(), getypos()-kh_distance
);
2103 gcpy # //right of slot
2104 gcpy # dxfline(
2105 gcpy #     getxpos()+tool_diameter(KH_tool_num, (kh_max_depth))/2,
2106 gcpy #     getypos()-(math.sqrt((tool_diameter(KH_tool_num, 1)^2)-(
tool_diameter(KH_tool_num, 5)^2))/2), //( (kh_max_depth-6.34))
/2)^2-(tool_diameter(KH_tool_num, (kh_max_depth-6.34))/2)^2,
2107 gcpy #     getxpos()+tool_diameter(KH_tool_num, (kh_max_depth))/2,
2108 gcpy # //end position at top of slot
2109 gcpy #     getypos()-kh_distance,
2110 gcpy #     KH_tool_num);
2111 gcpy # //left of slot
2112 gcpy # dxfline(
2113 gcpy #     getxpos()-tool_diameter(KH_tool_num, (kh_max_depth))/2,
2114 gcpy #     getypos()-(math.sqrt((tool_diameter(KH_tool_num, 1)^2)-(
tool_diameter(KH_tool_num, 5)^2))/2), //( (kh_max_depth-6.34))
/2)^2-(tool_diameter(KH_tool_num, (kh_max_depth-6.34))/2)^2,
2115 gcpy #     getxpos()-tool_diameter(KH_tool_num, (kh_max_depth))/2,
2116 gcpy # //end position at top of slot
2117 gcpy #     getypos()-kh_distance,
2118 gcpy #     KH_tool_num);
2119 gcpy # //Lower right of entry hole
2120 gcpy # dxffarc(getxpos(), getypos(), 9.525/2, 360-acos(tool_diameter(
KH_tool_num, 5)/tool_diameter(KH_tool_num, 1)), 360, KH_tool_num
);
2121 gcpy # //Lower left of entry hole
2122 gcpy # dxffarc(getxpos(), getypos(), 9.525/2, 180, 180+acos(
tool_diameter(KH_tool_num, 5)/tool_diameter(KH_tool_num, 1)),
KH_tool_num);
2123 gcpy # hull(){
2124 gcpy #     translate([xpos(), ypos(), zpos()]){
2125 gcpy #         keyhole_shaft(6.35, 9.525);
2126 gcpy #     }
2127 gcpy #     translate([xpos(), ypos(), zpos()-kh_max_depth]){
2128 gcpy #         keyhole_shaft(6.35, 9.525);
2129 gcpy #     }
2130 gcpy # }
2131 gcpy # hull(){
2132 gcpy #     translate([xpos(), ypos(), zpos()-kh_max_depth]){
2133 gcpy #         keyhole_shaft(6.35, 9.525);
2134 gcpy #     }
2135 gcpy #     translate([xpos(), ypos()-kh_distance, zpos()-kh_max_depth])
{
2136 gcpy #         keyhole_shaft(6.35, 9.525);
2137 gcpy #     }
2138 gcpy # }
2139 gcpy # cutwithfeed(getxpos(), getypos(), -kh_max_depth, feed);
2140 gcpy # cutwithfeed(getxpos(), getypos()-kh_distance, -kh_max_depth,
feed);
2141 gcpy # setypos(getypos()+kh_distance);
2142 gcpy # }
2143 gcpy #}

```

3.7.0.2.4 Dovetail joinery and tooling One focus of this project from the beginning has been cutting joinery. The first such toolpath to be developed is half-blind dovetails, since they are intrinsically simple to calculate since their geometry is dictated by the geometry of the tool.

BlocksCAD project page at: <https://www.blocks cad3d.com/community/projects/1941456>
and discussion at: <https://community.carbide3d.com/t/tool-paths-for-different-sized-dovetail-bit-89098>

Making such cuts will require dovetail tooling such as:

- 808079 <https://www.amanatool.com/45828-carbide-tipped-dovetail-8-deg-x-1-2-dia-x-825-x-1.html>
- 814 <https://www.leevalley.com/en-us/shop/tools/power-tool-accessories/router-bits/30172-dovetail-bits?item=18J1607>

Two commands are required:

```

2145 gcpy     def cut_pins(self, Joint_Width, stockZthickness,
                Number_of_Dovetails, Spacing, Proportion, DTT_diameter,
                DTT_angle):
2146 gcpy         DT0 = Tan(math.radians(DTT_angle)) * (stockZthickness *
                Proportion)

```

```

2147 gcpy          DTR = DTT_diameter/2 - DT0
2148 gcpy          cpr = self.rapidXY(0, stockZthickness + Spacing/2)
2149 gcpy          ctp = self.cutlinedxfgc(self.xpos(), self.ypos(), -
                stockZthickness * Proportion)
2150 gcpy #          ctp = ctp.union(self.cutlinedxfgc(Joint_Width / (
                Number_of_Dovetails * 2), self.ypos(), -stockZthickness *
                Proportion))
2151 gcpy          i = 1
2152 gcpy          while i < Number_of_Dovetails * 2:
2153 gcpy #              print(i)
2154 gcpy              ctp = ctp.union(self.cutlinedxfgc(i * (Joint_Width / (
                Number_of_Dovetails * 2)), self.ypos(), -
                stockZthickness * Proportion))
2155 gcpy              ctp = ctp.union(self.cutlinedxfgc(i * (Joint_Width / (
                Number_of_Dovetails * 2)), (stockZthickness +
                Spacing) + (stockZthickness * Proportion) - (
                DTT_diameter/2), -(stockZthickness * Proportion)))
2156 gcpy              ctp = ctp.union(self.cutlinedxfgc(i * (Joint_Width / (
                Number_of_Dovetails * 2)), stockZthickness + Spacing
                /2, -(stockZthickness * Proportion)))
2157 gcpy              ctp = ctp.union(self.cutlinedxfgc((i + 1) * (
                Joint_Width / (Number_of_Dovetails * 2)),
                stockZthickness + Spacing/2, -(stockZthickness *
                Proportion)))
2158 gcpy              self.dxfrectangleround(self.currenttoolnumber(),
2159 gcpy                  i * (Joint_Width / (Number_of_Dovetails * 2))-DTR,
2160 gcpy                  stockZthickness + (Spacing/2) - DTR,
2161 gcpy                  DTR * 2,
2162 gcpy                  (stockZthickness * Proportion) + Spacing/2 + DTR *
                2 - (DTT_diameter/2),
2163 gcpy                  DTR)
2164 gcpy              i += 2
2165 gcpy          self.rapidZ(0)
2166 gcpy          return ctp

```

and

```

2168 gcpy          def cut_tails(self, Joint_Width, stockZthickness,
                Number_of_Dovetails, Spacing, Proportion, DTT_diameter,
                DTT_angle):
2169 gcpy              DT0 = Tan(math.radians(DTT_angle)) * (stockZthickness *
                Proportion)
2170 gcpy              DTR = DTT_diameter/2 - DT0
2171 gcpy              cpr = self.rapidXY(0, 0)
2172 gcpy              ctp = self.cutlinedxfgc(self.xpos(), self.ypos(), -
                stockZthickness * Proportion)
2173 gcpy              ctp = ctp.union(self.cutlinedxfgc(
2174 gcpy                  Joint_Width / (Number_of_Dovetails * 2) - (DTT_diameter
                - DT0),
2175 gcpy                  self.ypos(),
2176 gcpy                  -stockZthickness * Proportion))
2177 gcpy              i = 1
2178 gcpy              while i < Number_of_Dovetails * 2:
2179 gcpy                  ctp = ctp.union(self.cutlinedxfgc(
2180 gcpy                      i * (Joint_Width / (Number_of_Dovetails * 2)) - (
                DTT_diameter - DT0),
2181 gcpy                      stockZthickness * Proportion - DTT_diameter / 2,
2182 gcpy                      -(stockZthickness * Proportion)))
2183 gcpy                  ctp = ctp.union(self.cutarcCWdxf(180, 90,
2184 gcpy                      i * (Joint_Width / (Number_of_Dovetails * 2)),
2185 gcpy                      stockZthickness * Proportion - DTT_diameter / 2,
2186 gcpy #                      self.ypos(),
2187 gcpy                      DTT_diameter - DT0, 0, 1))
2188 gcpy                  ctp = ctp.union(self.cutarcCWdxf(90, 0,
2189 gcpy                      i * (Joint_Width / (Number_of_Dovetails * 2)),
2190 gcpy                      stockZthickness * Proportion - DTT_diameter / 2,
2191 gcpy                      DTT_diameter - DT0, 0, 1))
2192 gcpy                  ctp = ctp.union(self.cutlinedxfgc(
2193 gcpy                      i * (Joint_Width / (Number_of_Dovetails * 2)) + (
                DTT_diameter - DT0),
2194 gcpy                      0,
2195 gcpy                      -(stockZthickness * Proportion)))
2196 gcpy                  ctp = ctp.union(self.cutlinedxfgc(
2197 gcpy                      (i + 2) * (Joint_Width / (Number_of_Dovetails * 2))
                - (DTT_diameter - DT0),
2198 gcpy                      0,
2199 gcpy                      -(stockZthickness * Proportion)))
2200 gcpy              i += 2

```

```
2201 gcpy          self.rapidZ(0)
2202 gcpy          self.rapidXY(0, 0)
2203 gcpy          ctp = ctp.union(self.cutlinedxfgc(self.xpos(), self.ypos(),
2204 gcpy              -stockZthickness * Proportion))
2205 gcpy          self.dxfarc(self.currenttoolnumber(), 0, 0, DTR, 180, 270)
2206 gcpy          self.dxfline(self.currenttoolnumber(), -DTR, 0, -DTR,
2207 gcpy              stockZthickness + DTR)
2208 gcpy          self.dxfarc(self.currenttoolnumber(), 0, stockZthickness +
2209 gcpy              DTR, DTR, 90, 180)
2210 gcpy          self.dxfline(self.currenttoolnumber(), 0, stockZthickness +
2211 gcpy              DTR * 2, Joint_Width, stockZthickness + DTR * 2)
2212 gcpy          i = 0
2213 gcpy          while i < Number_of_Dovetails * 2:
2214 gcpy              ctp = ctp.union(self.cutline(i * (Joint_Width / (
2215 gcpy                  Number_of_Dovetails * 2)), stockZthickness + DT0, -(
2216 gcpy                      stockZthickness * Proportion)))
2217 gcpy              ctp = ctp.union(self.cutline((i+2) * (Joint_Width / (
2218 gcpy                  Number_of_Dovetails * 2)), stockZthickness + DT0, -(
2219 gcpy                      stockZthickness * Proportion)))
2220 gcpy              ctp = ctp.union(self.cutline((i+2) * (Joint_Width / (
2221 gcpy                  Number_of_Dovetails * 2)), 0, -(stockZthickness *
2222 gcpy                      Proportion)))
2223 gcpy              self.dxfarc(self.currenttoolnumber(), i * (Joint_Width
2224 gcpy                  / (Number_of_Dovetails * 2)), 0, DTR, 270, 360)
2225 gcpy              self.dxfline(self.currenttoolnumber(),
2226 gcpy                  i * (Joint_Width / (Number_of_Dovetails * 2)) + DTR
2227 gcpy                  ,
2228 gcpy                  0,
2229 gcpy                  i * (Joint_Width / (Number_of_Dovetails * 2)) + DTR
2230 gcpy                  , stockZthickness * Proportion - DTT_diameter /
2231 gcpy                  2)
2232 gcpy              self.dxfarc(self.currenttoolnumber(), (i + 1) * (
2233 gcpy                  Joint_Width / (Number_of_Dovetails * 2)),
2234 gcpy                  stockZthickness * Proportion - DTT_diameter / 2, (
2235 gcpy                      Joint_Width / (Number_of_Dovetails * 2)) - DTR, 90,
2236 gcpy                      180)
2237 gcpy              self.dxfarc(self.currenttoolnumber(), (i + 1) * (
2238 gcpy                  Joint_Width / (Number_of_Dovetails * 2)),
2239 gcpy                  stockZthickness * Proportion - DTT_diameter / 2, (
2240 gcpy                      Joint_Width / (Number_of_Dovetails * 2)) - DTR, 0,
2241 gcpy                      90)
2242 gcpy              self.dxfline(self.currenttoolnumber(),
2243 gcpy                  (i + 2) * (Joint_Width / (Number_of_Dovetails * 2))
2244 gcpy                  - DTR,
2245 gcpy                  0,
2246 gcpy                  (i + 2) * (Joint_Width / (Number_of_Dovetails * 2))
2247 gcpy                  - DTR, stockZthickness * Proportion -
2248 gcpy                      DTT_diameter / 2)
2249 gcpy              self.dxfarc(self.currenttoolnumber(), (i + 2) * (
2250 gcpy                  Joint_Width / (Number_of_Dovetails * 2)), 0, DTR,
2251 gcpy                  180, 270)
2252 gcpy              i += 2
2253 gcpy              self.dxfarc(self.currenttoolnumber(), Joint_Width,
2254 gcpy                  stockZthickness + DTR, DTR, 0, 90)
2255 gcpy              self.dxfline(self.currenttoolnumber(), Joint_Width + DTR,
2256 gcpy                  stockZthickness + DTR, Joint_Width + DTR, 0)
2257 gcpy              self.dxfarc(self.currenttoolnumber(), Joint_Width, 0, DTR,
2258 gcpy                  270, 360)
2259 gcpy              return ctp
```

which are used as:

```
toolpaths = gcp.cut_pins(stockXwidth, stockZthickness, Number_of_Dovetails, Spacing, Proportion, DTT_diameter)
toolpaths.append(gcp.cut_tails(stockXwidth, stockZthickness, Number_of_Dovetails, Spacing, Proportion, DTT_diameter))
```

Future versions may adjust the parameters passed in, having them calculate from the specifications for the currently active dovetail tool.

3.7.0.2.5 Full-blind box joints BlocksCAD project page at: <https://www.blocks cad3d.com/community/projects/1943966> and discussion at: <https://community.carbide3d.com/t/full-blind-box-joints-in-carbide-create/53329>

Full-blind box joints will require 3 separate tools:

- small V tool — this will be needed to make a cut along the edge of the joint
- small square tool — this should be the same diameter as the small V tool

- large V tool — this will facilitate the stock being of a greater thickness and avoid the need to make multiple cuts to cut the blind miters at the ends of the joint

Two different versions of the commands will be necessary, one for each orientation:

- horizontal
- vertical

and then the internal commands for each side will in turn need separate versions:

```

2231 gcpy      def Full_Blind_Finger_Joint_square(self, bx, by, orientation,
                side, width, thickness, Number_of_Pins, largeVdiameter,
                smallDiameter, normalormirror = "Default"):
2232 gcpy      # Joint_Orientation = "Horizontal" "Even" == "Lower", "Odd" ==
                "Upper"
2233 gcpy      # Joint_Orientation = "Vertical" "Even" == "Left", "Odd" == "
                Right"
2234 gcpy      if (orientation == "Vertical"):
2235 gcpy          if (normalormirror == "Default" and side != "Both"):
2236 gcpy              if (side == "Left"):
2237 gcpy                  normalormirror = "Even"
2238 gcpy              if (side == "Right"):
2239 gcpy                  normalormirror = "Odd"
2240 gcpy      if (orientation == "Horizontal"):
2241 gcpy          if (normalormirror == "Default" and side != "Both"):
2242 gcpy              if (side == "Lower"):
2243 gcpy                  normalormirror = "Even"
2244 gcpy              if (side == "Upper"):
2245 gcpy                  normalormirror = "Odd"
2246 gcpy      Finger_Width = ((Number_of_Pins * 2) - 1) * smallDiameter *
                1.1
2247 gcpy      Finger-Origin = width/2 - Finger_Width/2
2248 gcpy      rapid = self.rapidZ(0)
2249 gcpy      self.setdxcolor("Cyan")
2250 gcpy      rapid = rapid.union(self.rapidXY(bx, by))
2251 gcpy      toolpath = (self.Finger_Joint_square(bx, by, orientation,
                side, width, thickness, Number_of_Pins, Finger-Origin,
                smallDiameter))
2252 gcpy      if (orientation == "Vertical"):
2253 gcpy          if (side == "Both"):
2254 gcpy              toolpath = self.cutrectanglerounddx(self.
                currenttoolnum, bx - (thickness - smallDiameter
                /2), by-smallDiameter/2, 0, (thickness * 2) -
                smallDiameter, width+smallDiameter, (
                smallDiameter / 2) / Tan(math.radians(45)),
                smallDiameter/2)
2255 gcpy          if (side == "Left"):
2256 gcpy              toolpath = self.cutrectanglerounddx(self.
                currenttoolnum, bx - (smallDiameter/2), by-
                smallDiameter/2, 0, thickness, width+
                smallDiameter, ((smallDiameter / 2) / Tan(math.
                radians(45))), smallDiameter/2)
2257 gcpy          if (side == "Right"):
2258 gcpy              toolpath = self.cutrectanglerounddx(self.
                currenttoolnum, bx - (thickness - smallDiameter
                /2), by-smallDiameter/2, 0, thickness, width+
                smallDiameter, ((smallDiameter / 2) / Tan(math.
                radians(45))), smallDiameter/2)
2259 gcpy      toolpath = toolpath.union(self.Finger_Joint_square(bx, by,
                orientation, side, width, thickness, Number_of_Pins,
                Finger-Origin, smallDiameter))
2260 gcpy      if (orientation == "Horizontal"):
2261 gcpy          if (side == "Both"):
2262 gcpy              toolpath = self.cutrectanglerounddx(
                self.currenttoolnum,
2263 gcpy                  bx-smallDiameter/2,
2264 gcpy                  by - (thickness - smallDiameter/2),
2265 gcpy                  0,
2266 gcpy                  width+smallDiameter,
2267 gcpy                  (thickness * 2) - smallDiameter,
2268 gcpy                  (smallDiameter / 2) / Tan(math.radians(45)),
2269 gcpy                  smallDiameter/2)
2270 gcpy          if (side == "Lower"):
2271 gcpy              toolpath = self.cutrectanglerounddx(
                self.currenttoolnum,
2272 gcpy                  bx - (smallDiameter/2),
2273 gcpy                  by - smallDiameter/2,
2274 gcpy                  0,
2275 gcpy
2276 gcpy

```

```

2277 gcpy                width+smallDiameter,
2278 gcpy                thickness,
2279 gcpy                ((smallDiameter / 2) / Tan(math.radians(45))),
2280 gcpy                smallDiameter/2)
2281 gcpy                if (side == "Upper"):
2282 gcpy                    toolpath = self.cutrectanglerounddxf(
2283 gcpy                        self.currenttoolnum,
2284 gcpy                        bx - smallDiameter/2,
2285 gcpy                        by - (thickness - smallDiameter/2),
2286 gcpy                        0,
2287 gcpy                        width+smallDiameter,
2288 gcpy                        thickness,
2289 gcpy                        ((smallDiameter / 2) / Tan(math.radians(45))),
2290 gcpy                        smallDiameter/2)
2291 gcpy                toolpath = toolpath.union(self.Finger_Joint_square(bx, by,
                                orientation, side, width, thickness, Number_of_Pins,
                                Finger_Origin, smallDiameter))
2292 gcpy                return toolpath
2293 gcpy
2294 gcpy                def Finger_Joint_square(self, bx, by, orientation, side, width,
                                thickness, Number_of_Pins, Finger_Origin, smallDiameter,
                                normalormirror = "Default"):
2295 gcpy                    jointdepth = -(thickness - (smallDiameter / 2) / Tan(math.
                                radians(45)))
2296 gcpy                    # Joint_Orientation = "Horizontal" "Even" == "Lower", "Odd" ==
                                "Upper"
2297 gcpy                    # Joint_Orientation = "Vertical" "Even" == "Left", "Odd" == "
                                Right"
2298 gcpy                    if (orientation == "Vertical"):
2299 gcpy                        if (normalormirror == "Default" and side != "Both"):
2300 gcpy                            if (side == "Left"):
2301 gcpy                                normalormirror = "Even"
2302 gcpy                            if (side == "Right"):
2303 gcpy                                normalormirror = "Odd"
2304 gcpy                    if (orientation == "Horizontal"):
2305 gcpy                        if (normalormirror == "Default" and side != "Both"):
2306 gcpy                            if (side == "Lower"):
2307 gcpy                                normalormirror = "Even"
2308 gcpy                            if (side == "Upper"):
2309 gcpy                                normalormirror = "Odd"
2310 gcpy                    radius = smallDiameter/2
2311 gcpy                    jointwidth = thickness - smallDiameter
2312 gcpy                    toolpath = self.currenttool()
2313 gcpy                    rapid = self.rapidZ(0)
2314 gcpy                    self.setdxfcolor("Blue")
2315 gcpy                    toolpath = toolpath.union(self.cutlineZgcfeed(jointdepth
                                ,1000))
2316 gcpy                    self.beginpolyline(self.currenttool())
2317 gcpy                    if (orientation == "Vertical"):
2318 gcpy                        rapid = rapid.union(self.rapidXY(bx, by + Finger_Origin
                                ))
2319 gcpy                    self.addvertex(self.currenttoolnumber(), self.xpos(),
                                self.ypos())
2320 gcpy                    toolpath = toolpath.union(self.cutlineZgcfeed(
                                jointdepth,1000))
2321 gcpy                    i = 0
2322 gcpy                    while i <= Number_of_Pins - 1:
2323 gcpy                        if (side == "Right"):
2324 gcpy                            toolpath = toolpath.union(self.cutvertexdxf(
                                self.xpos(), self.ypos() + smallDiameter +
                                radius/5, jointdepth))
2325 gcpy                        if (side == "Left" or side == "Both"):
2326 gcpy                            toolpath = toolpath.union(self.cutvertexdxf(
                                self.xpos(), self.ypos() + radius,
                                jointdepth))
2327 gcpy                            toolpath = toolpath.union(self.cutvertexdxf(
                                self.xpos() + jointwidth, self.ypos(),
                                jointdepth))
2328 gcpy                            toolpath = toolpath.union(self.cutvertexdxf(
                                self.xpos(), self.ypos() + radius/5,
                                jointdepth))
2329 gcpy                            toolpath = toolpath.union(self.cutvertexdxf(
                                self.xpos() - jointwidth, self.ypos(),
                                jointdepth))
2330 gcpy                            toolpath = toolpath.union(self.cutvertexdxf(
                                self.xpos(), self.ypos() + radius,
                                jointdepth))
2331 gcpy                            if (side == "Left"):

```



```

2332 gcpy                toolpath = toolpath.union(self.cutvertexdx(
                        self.xpos(), self.ypos() + smallDiameter +
                        radius/5, jointdepth))
2333 gcpy                if (side == "Right" or side == "Both"):
2334 gcpy                    if (i < (Number_of_Pins - 1)):
2335 gcpy                        # print(i)
2336 gcpy                    toolpath = toolpath.union(self.cutvertexdx(
                        self.xpos(), self.ypos() + radius,
                        jointdepth))
2337 gcpy                toolpath = toolpath.union(self.cutvertexdx(
                        self.xpos() - jointwidth, self.ypos(),
                        jointdepth))
2338 gcpy                toolpath = toolpath.union(self.cutvertexdx(
                        self.xpos(), self.ypos() + radius/5,
                        jointdepth))
2339 gcpy                toolpath = toolpath.union(self.cutvertexdx(
                        self.xpos() + jointwidth, self.ypos(),
                        jointdepth))
2340 gcpy                toolpath = toolpath.union(self.cutvertexdx(
                        self.xpos(), self.ypos() + radius,
                        jointdepth))

2341 gcpy                i += 1
2342 gcpy                # Joint_Orientation = "Horizontal" "Even" == "Lower", "Odd" ==
                        "Upper"
2343 gcpy                if (orientation == "Horizontal"):
2344 gcpy                    rapid = rapid.union(self.rapidXY(bx + Finger_Origin, by
                        ))
2345 gcpy                    self.addvertex(self.currenttoolnumber(), self.xpos(),
                        self.ypos())
2346 gcpy                toolpath = toolpath.union(self.cutlineZgcfeed(
                        jointdepth,1000))
2347 gcpy                i = 0
2348 gcpy                while i <= Number_of_Pins - 1:
2349 gcpy                    if (side == "Upper"):
2350 gcpy                        toolpath = toolpath.union(self.cutvertexdx(
                            self.xpos() + smallDiameter + radius/5, self
                            .ypos(), jointdepth))
2351 gcpy                    if (side == "Lower" or side == "Both"):
2352 gcpy                        toolpath = toolpath.union(self.cutvertexdx(
                            self.xpos() + radius, self.ypos(),
                            jointdepth))
2353 gcpy                        toolpath = toolpath.union(self.cutvertexdx(
                            self.xpos(), self.ypos() + jointwidth,
                            jointdepth))
2354 gcpy                        toolpath = toolpath.union(self.cutvertexdx(
                            self.xpos() + radius/5, self.ypos(),
                            jointdepth))
2355 gcpy                        toolpath = toolpath.union(self.cutvertexdx(
                            self.xpos(), self.ypos() - jointwidth,
                            jointdepth))
2356 gcpy                        toolpath = toolpath.union(self.cutvertexdx(
                            self.xpos() + radius, self.ypos(),
                            jointdepth))
2357 gcpy                    if (side == "Lower"):
2358 gcpy                        toolpath = toolpath.union(self.cutvertexdx(
                            self.xpos() + smallDiameter + radius/5, self
                            .ypos(), jointdepth))
2359 gcpy                    if (side == "Upper" or side == "Both"):
2360 gcpy                        if (i < (Number_of_Pins - 1)):
2361 gcpy                            # print(i)
2362 gcpy                        toolpath = toolpath.union(self.cutvertexdx(
                            self.xpos() + radius, self.ypos(),
                            jointdepth))
2363 gcpy                        toolpath = toolpath.union(self.cutvertexdx(
                            self.xpos(), self.ypos() - jointwidth,
                            jointdepth))
2364 gcpy                        toolpath = toolpath.union(self.cutvertexdx(
                            self.xpos() + radius/5, self.ypos(),
                            jointdepth))
2365 gcpy                        toolpath = toolpath.union(self.cutvertexdx(
                            self.xpos(), self.ypos() + jointwidth,
                            jointdepth))
2366 gcpy                        toolpath = toolpath.union(self.cutvertexdx(
                            self.xpos() + radius, self.ypos(),
                            jointdepth))

2367 gcpy                i += 1
2368 gcpy                self.closepolyline(self.currenttoolnumber())
2369 gcpy                return toolpath

```

```

2370 gcpy
2371 gcpy    def Full_Blind_Finger_Joint_smallV(self, bx, by, orientation,
        side, width, thickness, Number_of_Pins, largeVdiameter,
        smallDiameter):
2372 gcpy        rapid = self.rapidZ(0)
2373 gcpy        #    rapid = rapid.union(self.rapidXY(bx, by))
2374 gcpy        self.setdxfcolor("Red")
2375 gcpy        if (orientation == "Vertical"):
2376 gcpy            rapid = rapid.union(self.rapidXY(bx, by - smallDiameter
                /6))
2377 gcpy            toolpath = self.cutlineZgcfeed(-thickness,1000)
2378 gcpy            toolpath = self.cutlinedxfgc(bx, by + width +
                smallDiameter/6, - thickness)
2379 gcpy        if (orientation == "Horizontal"):
2380 gcpy            rapid = rapid.union(self.rapidXY(bx - smallDiameter/6,
                by))
2381 gcpy            toolpath = self.cutlineZgcfeed(-thickness,1000)
2382 gcpy            toolpath = self.cutlinedxfgc(bx + width + smallDiameter
                /6, by, -thickness)
2383 gcpy        #    rapid = self.rapidZ(0)
2384 gcpy
2385 gcpy        return toolpath
2386 gcpy
2387 gcpy    def Full_Blind_Finger_Joint_largeV(self, bx, by, orientation,
        side, width, thickness, Number_of_Pins, largeVdiameter,
        smallDiameter):
2388 gcpy        radius = smallDiameter/2
2389 gcpy        rapid = self.rapidZ(0)
2390 gcpy        Finger_Width = ((Number_of_Pins * 2) - 1) * smallDiameter *
        1.1
2391 gcpy        Finger-Origin = width/2 - Finger_Width/2
2392 gcpy        #    rapid = rapid.union(self.rapidXY(bx, by))
2393 gcpy        # Joint_Orientation = "Horizontal" "Even" == "Lower", "Odd" ==
        "Upper"
2394 gcpy        # Joint_Orientation = "Vertical" "Even" == "Left", "Odd" == "
        Right"
2395 gcpy        if (orientation == "Vertical"):
2396 gcpy            rapid = rapid.union(self.rapidXY(bx, by))
2397 gcpy            toolpath = self.cutlineZgcfeed(-thickness,1000)
2398 gcpy            toolpath = toolpath.union(self.cutlinedxfgc(bx, by +
                Finger-Origin, -thickness))
2399 gcpy            rapid = self.rapidZ(0)
2400 gcpy            rapid = rapid.union(self.rapidXY(bx, by + width -
                Finger-Origin))
2401 gcpy            self.setdxfcolor("Blue")
2402 gcpy            toolpath = toolpath.union(self.cutlineZgcfeed(-
                thickness,1000))
2403 gcpy            toolpath = toolpath.union(self.cutlinedxfgc(bx, by +
                width, -thickness))
2404 gcpy            if (side == "Left" or side == "Both"):
2405 gcpy                rapid = self.rapidZ(0)
2406 gcpy                self.setdxfcolor("Dark_Gray")
2407 gcpy                rapid = rapid.union(self.rapidXY(bx+thickness-(
                    smallDiameter / 2) / Tan(math.radians(45)), by -
                    radius/2))
2408 gcpy                toolpath = toolpath.union(self.cutlineZgcfeed(-(
                    smallDiameter / 2) / Tan(math.radians(45))
                    ,10000))
2409 gcpy                toolpath = toolpath.union(self.cutlinedxfgc(bx+
                    thickness-(smallDiameter / 2) / Tan(math.radians
                    (45)), by + width + radius/2, -(smallDiameter /
                    2) / Tan(math.radians(45))))
2410 gcpy                rapid = self.rapidZ(0)
2411 gcpy                self.setdxfcolor("Green")
2412 gcpy                rapid = rapid.union(self.rapidXY(bx+thickness/2, by
                    +width))
2413 gcpy                toolpath = toolpath.union(self.cutlineZgcfeed(-
                    thickness/2,1000))
2414 gcpy                toolpath = toolpath.union(self.cutlinedxfgc(bx+
                    thickness/2, by + width -thickness, -thickness
                    /2))
2415 gcpy                rapid = self.rapidZ(0)
2416 gcpy                rapid = rapid.union(self.rapidXY(bx+thickness/2, by
                    ))
2417 gcpy                toolpath = toolpath.union(self.cutlineZgcfeed(-
                    thickness/2,1000))
2418 gcpy                toolpath = toolpath.union(self.cutlinedxfgc(bx+
                    thickness/2, by +thickness, -thickness/2))

```

```

2419 gcpy          if (side == "Right" or side == "Both"):
2420 gcpy              rapid = self.rapidZ(0)
2421 gcpy              self.setdxfcolor("Dark_Gray")
2422 gcpy              rapid = rapid.union(self.rapidXY(bx-(thickness-(
                    smallDiameter / 2) / Tan(math.radians(45))), by
                    - radius/2))
2423 gcpy              toolpath = toolpath.union(self.cutlineZgcfeed(-(
                    smallDiameter / 2) / Tan(math.radians(45))
                    ,10000))
2424 gcpy              toolpath = toolpath.union(self.cutlinedxfgc(bx-(
                    thickness-(smallDiameter / 2) / Tan(math.radians
                    (45))), by + width + radius/2, -(smallDiameter /
                    2) / Tan(math.radians(45))))
2425 gcpy              rapid = self.rapidZ(0)
2426 gcpy              self.setdxfcolor("Green")
2427 gcpy              rapid = rapid.union(self.rapidXY(bx-thickness/2, by
                    +width))
2428 gcpy              toolpath = toolpath.union(self.cutlineZgcfeed(-
                    thickness/2,1000))
2429 gcpy              toolpath = toolpath.union(self.cutlinedxfgc(bx-
                    thickness/2, by + width -thickness, -thickness
                    /2))
2430 gcpy              rapid = self.rapidZ(0)
2431 gcpy              rapid = rapid.union(self.rapidXY(bx-thickness/2, by
                    ))
2432 gcpy              toolpath = toolpath.union(self.cutlineZgcfeed(-
                    thickness/2,1000))
2433 gcpy              toolpath = toolpath.union(self.cutlinedxfgc(bx-
                    thickness/2, by +thickness, -thickness/2))
2434 gcpy          # Joint_Orientation = "Horizontal" "Even" == "Lower", "Odd" ==
                    "Upper"
2435 gcpy          if (orientation == "Horizontal"):
2436 gcpy              rapid = rapid.union(self.rapidXY(bx, by))
2437 gcpy              self.setdxfcolor("Blue")
2438 gcpy              toolpath = self.cutlineZgcfeed(-thickness,1000)
2439 gcpy              toolpath = toolpath.union(self.cutlinedxfgc(bx +
                    Finger-Origin, by, -thickness))
2440 gcpy              rapid = rapid.union(self.rapidZ(0))
2441 gcpy              rapid = rapid.union(self.rapidXY(bx + width -
                    Finger-Origin, by))
2442 gcpy              toolpath = toolpath.union(self.cutlineZgcfeed(-
                    thickness,1000))
2443 gcpy              toolpath = toolpath.union(self.cutlinedxfgc(bx + width,
                    by, -thickness))
2444 gcpy          if (side == "Lower" or side == "Both"):
2445 gcpy              rapid = self.rapidZ(0)
2446 gcpy              self.setdxfcolor("Dark_Gray")
2447 gcpy              rapid = rapid.union(self.rapidXY(bx - radius, by+
                    thickness-(smallDiameter / 2) / Tan(math.radians
                    (45))))
2448 gcpy              toolpath = toolpath.union(self.cutlineZgcfeed(-(
                    smallDiameter / 2) / Tan(math.radians(45))
                    ,10000))
2449 gcpy              toolpath = toolpath.union(self.cutlinedxfgc(bx +
                    width + radius, by+thickness-(smallDiameter / 2)
                    / Tan(math.radians(45))), -(smallDiameter / 2) /
                    Tan(math.radians(45))))
2450 gcpy              rapid = self.rapidZ(0)
2451 gcpy              self.setdxfcolor("Green")
2452 gcpy              rapid = rapid.union(self.rapidXY(bx+width, by+
                    thickness/2))
2453 gcpy              toolpath = toolpath.union(self.cutlineZgcfeed(-
                    thickness/2,1000))
2454 gcpy              toolpath = toolpath.union(self.cutlinedxfgc(bx +
                    width -thickness, by+thickness/2, -thickness/2))
2455 gcpy              rapid = self.rapidZ(0)
2456 gcpy              rapid = rapid.union(self.rapidXY(bx, by+thickness
                    /2))
2457 gcpy              toolpath = toolpath.union(self.cutlineZgcfeed(-
                    thickness/2,1000))
2458 gcpy              toolpath = toolpath.union(self.cutlinedxfgc(bx +
                    thickness, by+thickness/2, -thickness/2))
2459 gcpy          if (side == "Upper" or side == "Both"):
2460 gcpy              rapid = self.rapidZ(0)
2461 gcpy              self.setdxfcolor("Dark_Gray")
2462 gcpy              rapid = rapid.union(self.rapidXY(bx - radius, by-(
                    thickness-(smallDiameter / 2) / Tan(math.radians
                    (45))))))

```

```
2463 gcpy          toolpath = toolpath.union(self.cutlineZgcfeed(-(
                    smallDiameter / 2) / Tan(math.radians(45))
                    ,10000))
2464 gcpy          toolpath = toolpath.union(self.cutlinedxfgc(bx +
                    width + radius, by-(thickness-(smallDiameter /
                    2) / Tan(math.radians(45))), -(smallDiameter /
                    2) / Tan(math.radians(45))))
2465 gcpy          rapid = self.rapidZ(0)
2466 gcpy          self.setdxfcolor("Green")
2467 gcpy          rapid = rapid.union(self.rapidXY(bx+width, by-
                    thickness/2))
2468 gcpy          toolpath = toolpath.union(self.cutlineZgcfeed(-
                    thickness/2,1000))
2469 gcpy          toolpath = toolpath.union(self.cutlinedxfgc(bx +
                    width -thickness, by-thickness/2, -thickness/2))
2470 gcpy          rapid = self.rapidZ(0)
2471 gcpy          rapid = rapid.union(self.rapidXY(bx, by-thickness
                    /2))
2472 gcpy          toolpath = toolpath.union(self.cutlineZgcfeed(-
                    thickness/2,1000))
2473 gcpy          toolpath = toolpath.union(self.cutlinedxfgc(bx +
                    thickness, by-thickness/2, -thickness/2))
2474 gcpy          rapid = self.rapidZ(0)
2475 gcpy          return toolpath
2476 gcpy
2477 gcpy          def Full_Blind_Finger_Joint(self, bx, by, orientation, side,
                    width, thickness, largeVdiameter, smallDiameter,
                    normalormirror = "Default", squaretool = 102, smallV = 390,
                    largeV = 301):
2478 gcpy          Number_of_Pins = int((((width - thickness * 2) / (
                    smallDiameter * 2.2) / 2)+ 0.0) * 2 + 1
2479 gcpy          # print("Number of Pins: ",Number_of_Pins)
2480 gcpy          self.movetosafeZ()
2481 gcpy          self.toolchange(squaretool, 17000)
2482 gcpy          toolpath = self.Full_Blind_Finger_Joint_square(bx, by,
                    orientation, side, width, thickness, Number_of_Pins,
                    largeVdiameter, smallDiameter)
2483 gcpy          self.movetosafeZ()
2484 gcpy          self.toolchange(smallV, 17000)
2485 gcpy          toolpath = toolpath.union(self.
                    Full_Blind_Finger_Joint_smallV(bx, by, orientation, side
                    , width, thickness, Number_of_Pins, largeVdiameter,
                    smallDiameter))
2486 gcpy          self.toolchange(largeV, 17000)
2487 gcpy          toolpath = toolpath.union(self.
                    Full_Blind_Finger_Joint_largeV(bx, by, orientation, side
                    , width, thickness, Number_of_Pins, largeVdiameter,
                    smallDiameter))
2488 gcpy          return toolpath
```

3.8 (Reading) G-code Files

With all other features in place, it becomes possible to read in a G-code file and then create a 3D preview of how it will cut.
First, a template file will be necessary:

```
1 gcpgccpy from openscad import *
2 gcpgccpy #nimport("https://raw.githubusercontent.com/WillAdams/gcodepreview/
                    refs/heads/main/gcodepreview.py")
3 gcpgccpy
4 gcpgccpy from gcodepreview import *
5 gcpgccpy
6 gcpgccpy gc_file = "filename_of_G-code_file_to_process.nc"
7 gcpgccpy
8 gcpgccpy gcp = gcodepreview(False, False)
9 gcpgccpy
10 gcpgccpy gcp.previewgcodefile(gc_file)
```

previewgcodefile Which simply needs to call the previewgcodefile command:

```
2490 gcpy          def previewgcodefile(self, gc_file):
2491 gcpy          gc_file = open(gc_file, 'r')
2492 gcpy          gcfilecontents = []
2493 gcpy          with gc_file as file:
2494 gcpy          for line in file:
2495 gcpy          command = line
```

```

2496 gcpy          gcfilecontents.append(line)
2497 gcpy
2498 gcpy          numlinesfound = 0
2499 gcpy          for line in gcfilecontents:
2500 gcpy #              print(line)
2501 gcpy                  if line[:10] == "(stockMin:":
2502 gcpy                      subdivisions = line.split()
2503 gcpy                      extentleft = float(subdivisions[0][10:-3])
2504 gcpy                      extentfb = float(subdivisions[1][: -3])
2505 gcpy                      extentd = float(subdivisions[2][: -3])
2506 gcpy                      numlinesfound = numlinesfound + 1
2507 gcpy                  if line[:13] == "(STOCK/BLOCK,":
2508 gcpy                      subdivisions = line.split()
2509 gcpy                      sizeX = float(subdivisions[0][13:-1])
2510 gcpy                      sizeY = float(subdivisions[1][: -1])
2511 gcpy                      sizeZ = float(subdivisions[4][: -1])
2512 gcpy                      numlinesfound = numlinesfound + 1
2513 gcpy                  if line[:3] == "G21":
2514 gcpy                      units = "mm"
2515 gcpy                      numlinesfound = numlinesfound + 1
2516 gcpy                  if numlinesfound >=3:
2517 gcpy                      break
2518 gcpy #              print(numlinesfound)
2519 gcpy
2520 gcpy          self.setupcuttingarea(sizeX, sizeY, sizeZ, extentleft,
2521                                     extentfb, extentd)
2522 gcpy
2523 gcpy          commands = []
2524 gcpy          for line in gcfilecontents:
2525 gcpy              Xc = 0
2526 gcpy              Yc = 0
2527 gcpy              Zc = 0
2528 gcpy              Fc = 0
2529 gcpy              Xp = 0.0
2530 gcpy              Yp = 0.0
2531 gcpy              Zp = 0.0
2532 gcpy              if line == "G53G0Z-5.000\n":
2533 gcpy                  self.movetosafeZ()
2534 gcpy              if line[:3] == "M6T":
2535 gcpy                  tool = int(line[3:])
2536 gcpy                  self.toolchange(tool)
2537 gcpy              if line[:2] == "G0":
2538 gcpy                  machinestate = "rapid"
2539 gcpy              if line[:2] == "G1":
2540 gcpy                  machinestate = "cutline"
2541 gcpy              if line[:2] == "G0" or line[:2] == "G1" or line[:1] ==
2542 gcpy                  "X" or line[:1] == "Y" or line[:1] == "Z":
2543 gcpy                  if "F" in line:
2544 gcpy                      Fplus = line.split("F")
2545 gcpy                      Fc = 1
2546 gcpy                      fr = float(Fplus[1])
2547 gcpy                      line = Fplus[0]
2548 gcpy                  if "Z" in line:
2549 gcpy                      Zplus = line.split("Z")
2550 gcpy                      Zc = 1
2551 gcpy                      Zp = float(Zplus[1])
2552 gcpy                      line = Zplus[0]
2553 gcpy                  if "Y" in line:
2554 gcpy                      Yplus = line.split("Y")
2555 gcpy                      Yc = 1
2556 gcpy                      Yp = float(Yplus[1])
2557 gcpy                      line = Yplus[0]
2558 gcpy                  if "X" in line:
2559 gcpy                      Xplus = line.split("X")
2560 gcpy                      Xc = 1
2561 gcpy                      Xp = float(Xplus[1])
2562 gcpy                  if Zc == 1:
2563 gcpy                      if Yc == 1:
2564 gcpy                          if Xc == 1:
2565 gcpy                              if machinestate == "rapid":
2566 gcpy                                  command = "rapidXYZ(" + str(Xp) + "
2567 gcpy                                      ,\u" + str(Yp) + ",\u" + str(Zp) +
2568 gcpy                                      ")"
2569 gcpy                                  self.rapidXYZ(Xp, Yp, Zp)
2570 gcpy                              else:
2571 gcpy                                  command = "cutlineXYZ(" + str(Xp) +
2572 gcpy                                      ",\u" + str(Yp) + ",\u" + str(Zp)
2573 gcpy                                      + ")"

```

```

2568 gcpy                self.cutlineXYZ(Xp, Yp, Zp)
2569 gcpy                else:
2570 gcpy                    if machinestate == "rapid":
2571 gcpy                        command = "rapidYZ(" + str(Yp) + ",
                                "\u" + str(Zp) + ")"
                                self.rapidYZ(Yp, Zp)
2572 gcpy                else:
2573 gcpy                    command = "cutlineYZ(" + str(Yp) +
2574 gcpy                        ",\u" + str(Zp) + ")"
                                self.cutlineYZ(Yp, Zp)
2575 gcpy                else:
2576 gcpy                    if Xc == 1:
2577 gcpy                        if machinestate == "rapid":
2578 gcpy                            command = "rapidXZ(" + str(Xp) + ",
2579 gcpy                                "\u" + str(Zp) + ")"
                                self.rapidXZ(Xp, Zp)
2580 gcpy                else:
2581 gcpy                    command = "cutlineXZ(" + str(Xp) +
2582 gcpy                        ",\u" + str(Zp) + ")"
                                self.cutlineXZ(Xp, Zp)
2583 gcpy                else:
2584 gcpy                    if machinestate == "rapid":
2585 gcpy                        command = "rapidZ(" + str(Zp) + ")"
2586 gcpy                        self.rapidZ(Zp)
2587 gcpy                    else:
2588 gcpy                        command = "cutlineZ(" + str(Zp) + "
2589 gcpy                            )"
                                self.cutlineZ(Zp)
2590 gcpy                else:
2591 gcpy                    if Yc == 1:
2592 gcpy                        if Xc == 1:
2593 gcpy                            if machinestate == "rapid":
2594 gcpy                                command = "rapidXY(" + str(Xp) + ",
2595 gcpy                                    "\u" + str(Yp) + ")"
                                    self.rapidXY(Xp, Yp)
2596 gcpy                            else:
2597 gcpy                                command = "cutlineXY(" + str(Xp) +
2598 gcpy                                    ",\u" + str(Yp) + ")"
                                    self.cutlineXY(Xp, Yp)
2599 gcpy                else:
2600 gcpy                    if machinestate == "rapid":
2601 gcpy                        command = "rapidY(" + str(Yp) + ")"
2602 gcpy                        self.rapidY(Yp)
2603 gcpy                    else:
2604 gcpy                        command = "cutlineY(" + str(Yp) + "
2605 gcpy                            )"
                                    self.cutlineY(Yp)
2606 gcpy                else:
2607 gcpy                    if Xc == 1:
2608 gcpy                        if machinestate == "rapid":
2609 gcpy                            command = "rapidX(" + str(Xp) + ")"
2610 gcpy                            self.rapidX(Xp)
2611 gcpy                        else:
2612 gcpy                            command = "cutlineX(" + str(Xp) + "
2613 gcpy                                )"
                                    self.cutlineX(Xp)
2614 gcpy                commands.append(command)
2615 gcpy                print(line)
2616 gcpy #                print(command)
2617 gcpy #                print(machinestate, Xc, Yc, Zc)
2618 gcpy #                print(Xp, Yp, Zp)
2619 gcpy #                print("/n")
2620 gcpy #
2621 gcpy
2622 gcpy #                for command in commands:
2623 gcpy #                    print(command)
2624 gcpy
2625 gcpy #                show(self.stockandtoolpaths())
2626 gcpy                self.stockandtoolpaths()

```

4 Notes

4.1 Other Resources

4.1.1 Coding Style

A notable influence on the coding style in this project is John Ousterhout’s *A Philosophy of Software Design*[SoftwareDesign]. Complexity is managed by the overall design and structure of the code, structuring it so that each component may be worked with on an individual basis, hiding the maximum information, and exposing the maximum functionality, with names selected so as to express their functionality/usage.

Red Flags to avoid include:

- Shallow Module
- Information Leakage
- Temporal Decomposition
- Overexposure
- Pass-Through Method
- Repetition
- Special-General Mixture
- Conjoined Methods
- Comment Repeats Code
- Implementation Documentation Contaminates Interface
- Vague Name
- Hard to Pick Name
- Hard to Describe
- Nonobvious Code

4.1.2 Coding References

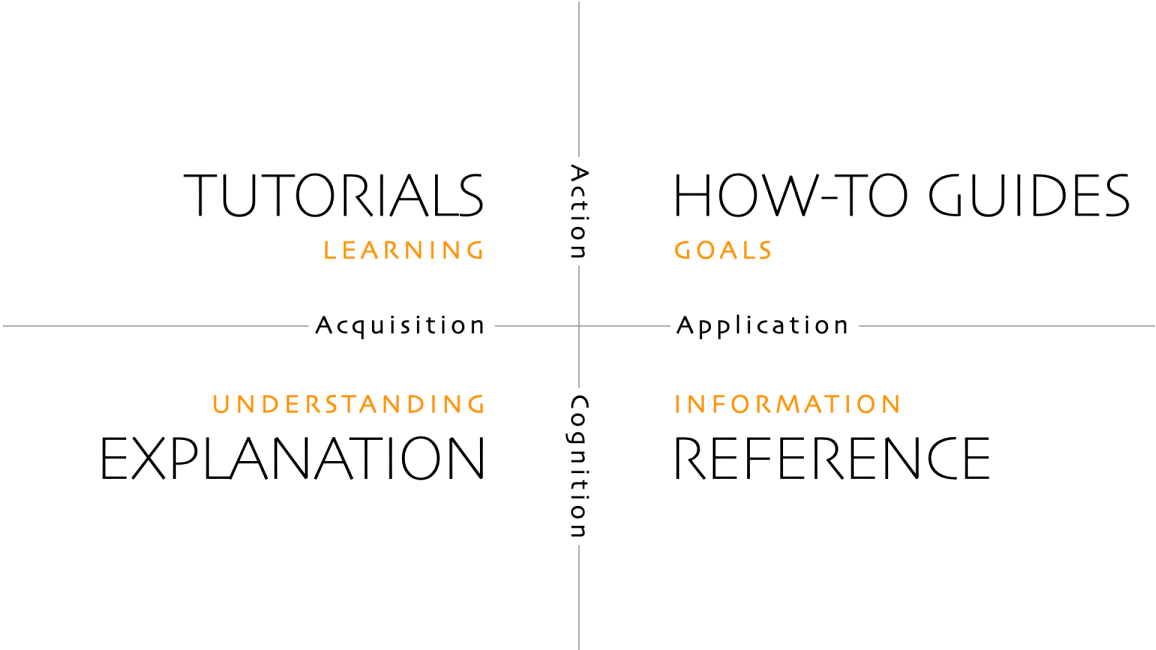
<https://thewhitetulip.gitbook.io/py/06-file-handling>

4.1.3 Documentation Style

<https://diataxis.fr/> (originally developed at: <https://docs.divio.com/documentation-system/>)
— divides documentation along two axes:

- Action (Practical) vs. Cognition (Theoretical)
- Acquisition (Studying) vs. Application (Working)

resulting in a matrix of:



where:

1. readme.md — (Overview) Explanation (understanding-oriented)
2. Templates — Tutorials (learning-oriented)
3. gcodepreview — How-to Guides (problem-oriented)
4. Index — Reference (information-oriented)

Straddling the boundary between coding and documentation are docstrings and general coding style with the latter discussed at: <https://peps.python.org/pep-0008/>

4.1.4 Holidays

Holidays are from <https://nationaltoday.com/>

4.1.5 DXFs

<http://www.paulbourke.net/dataformats/dxf/>
<https://paulbourke.net/dataformats/dxf/min3d.html>

4.2 Future

4.2.1 Images

Would it be helpful to re-create code algorithms/sections using OpenSCAD Graph Editor so as to represent/illustrate the program?

4.2.2 Bézier curves in 2 dimensions

Take a Bézier curve definition and approximate it as arcs and write them into a DXF?

<https://pomax.github.io/bezierinfo/>
<https://ciechanow.ski/curves-and-surfaces/>
<https://www.youtube.com/watch?v=aVwxzDHniEw>
 c.f., <https://linuxcnc.org/docs/html/gcode/g-code.html#gcode:g5>

4.2.3 Bézier curves in 3 dimensions

One question is how many Bézier curves would it be necessary to have to define a surface in 3 dimensions. Attributes for this which are desirable/necessary:

- concise — a given Bézier curve should be represented by just the point coordinates, so two on-curve points, two off-curve points, each with a pair of coordinates
- For a given shape/region it will need to be possible to have a matching definition exactly match up with it so that one could piece together a larger more complex shape from smaller/simpler regions
- similarly it will be necessary for it to be possible to sub-divide a defined region — for example it should be possible if one had 4 adjacent regions, then the four quadrants at the intersection of the four regions could be used to construct a new region — is it possible to derive a new Bézier curve from half of two other curves?

For the three planes:

- XY
- XZ
- ZY

it should be possible to have three Bézier curves (left-most/right-most or front-back or top/bottom for two, and a mid-line for the third), so a region which can be so represented would be definable by:

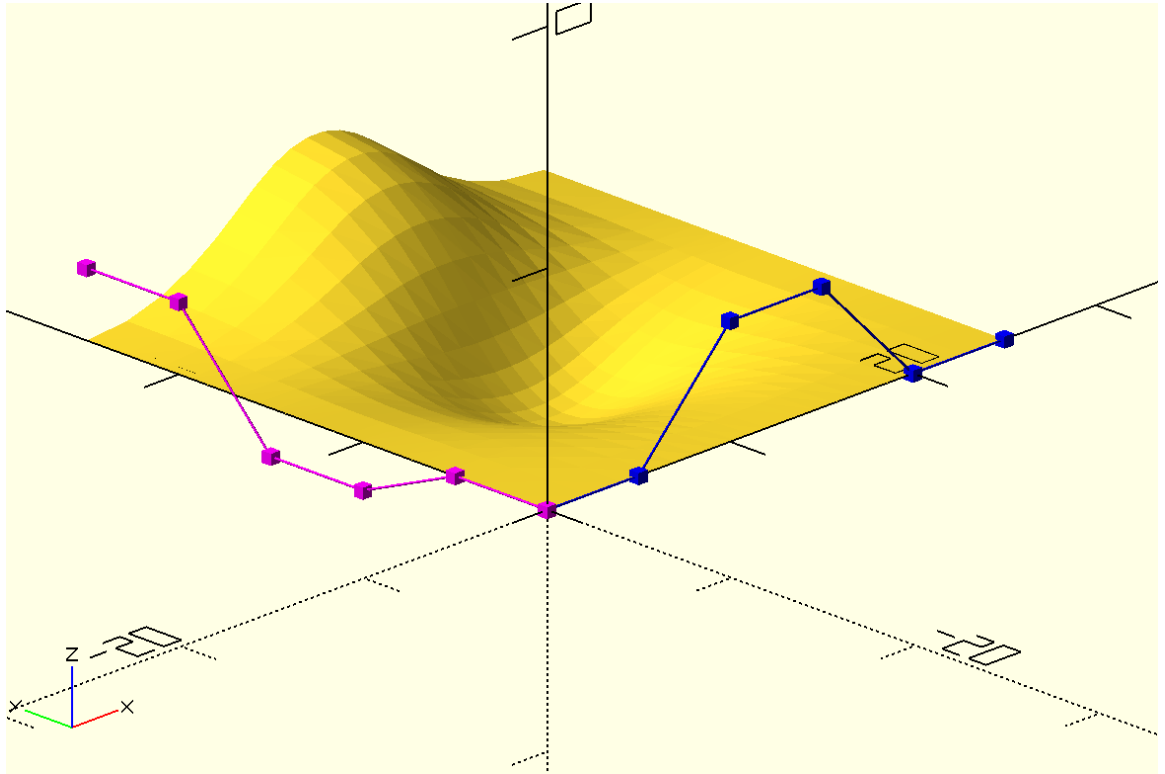
3 planes * 3 Béziers * (2 on-curve + 2 off-curve points) == 36 coordinate pairs

which is a marked contrast to representations such as:

<https://github.com/DavidPhillipOster/Teapot>

and regions which could not be so represented could be sub-divided until the representation is workable.

Or, it may be that fewer (only two?) curves are needed:



<https://pages.mtu.edu/~shene/COURSES/cs3621/NOTES/notes.html>
c.f., <https://github.com/BelfrySCAD/BOSL2/wiki/nurbs.scad> and https://old.reddit.com/r/OpenPythonSCAD/comments/1gjcz4z/pythonscad_will_get_a_new_spline_function/

4.2.4 Mathematics

<https://elementsofprogramming.com/>

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[SoftwareDesign]	Ousterhout, John K. <i>A Philosophy of Software Design</i> . First Edition., Yaknyam Press, Palo Alto, Ca., 2018

Command Glossary

. 25

setupstock setupstock(200, 100, 8.35, "Top", "Lower-left", 8.35). 23

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