Computational Fabrication

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

Final Project Proposals

https://handandmachine.org/classes/computational_fabrication/2023/10/10/final-project-proposal-4/

CS Researcher (Designer): Lining Yao

https://www.morphingmatter.cs.cmu.edu/

Data Physicalization Projects

CAD CAM

CAD CAM

computer aided design

CAD CAM

computer aided manufacturing

3D Printing Workflow

CAD: Rhino, Grasshopper, and Python: design your geometry.

CAM part 1: Cura (or other "slicer"): translate geometry into machine readable (g-code) file by slicing it layer by layer and generating a tool path for each layer.

CAM part 2: Transfer the g-code file to the 3D printer. 3D printer interprets the g-code, (follows the tool path) and generates your artifact.

G-Code

Machine Code

https://www.autodesk.com/products/fusion-360/blog/computer-aided-manufacturing-beginners/

G-Code Overview

The language of machines; the code that tells the 3D printer (or other machine) what to do.

G-Code file: a series of simple commands that are interpreted line by line by the machine. Each line is one integrated command.

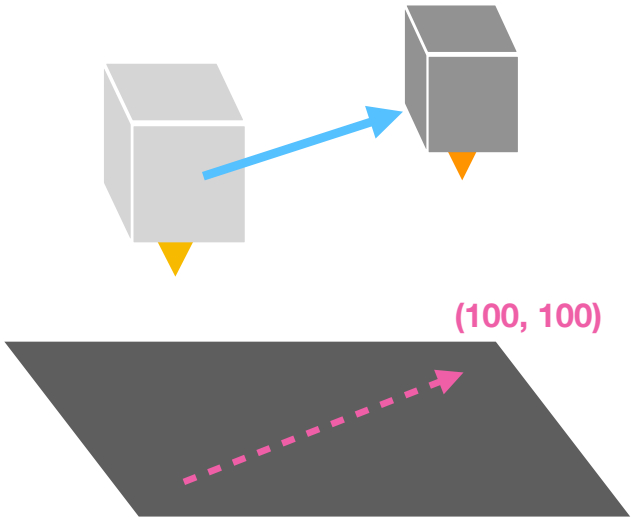
Basic elements of control:

- Movement of print head in x,y,z
- Extrusion of material (in one dimension)
- Temperature of bed and extruder ("hot end")

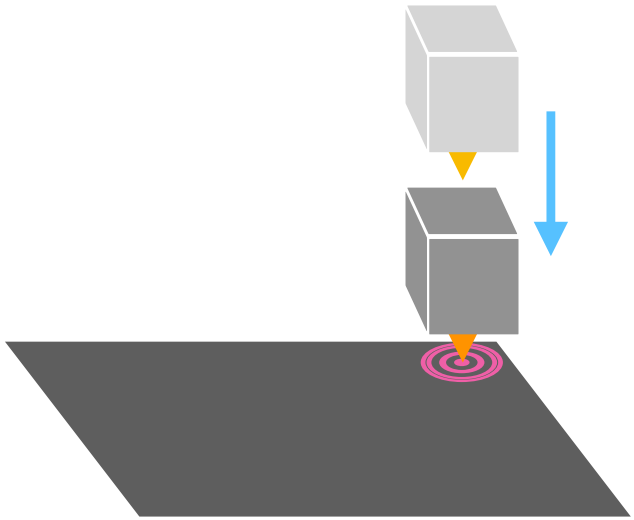
Command reference: https://reprap.org/wiki/G-code

Movement (mm) G1 or G01

```
G1 X100 Y100
```



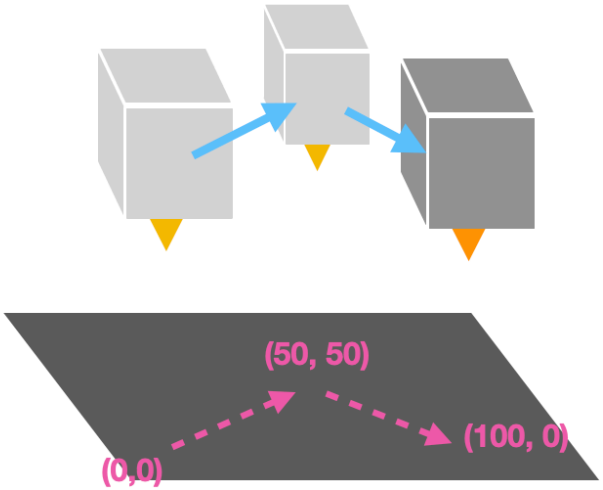

```
G1 Z1
```



Absolute (G90) vs. Relative (G91) Mode

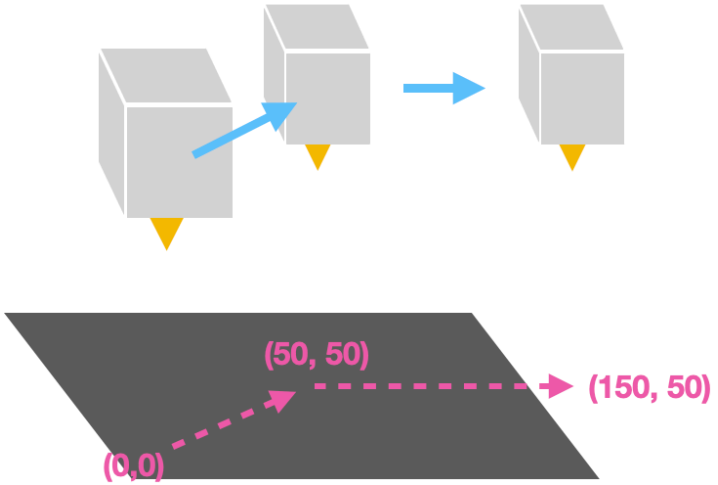
```
G90
G01 X50  Y50
G01 X100 Y0
```

(Absolute coordinates)



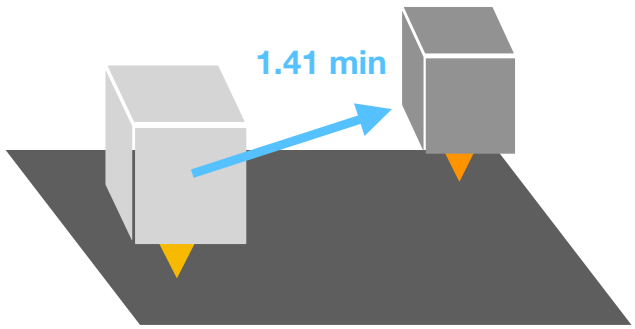

```
G91
G01 X50  Y50
G01 X100 Y0
```

(Relative coordinates)



Speed, AKA “Feedrate” (mm/minute) F

```
G01 X100 Y100 F100
```

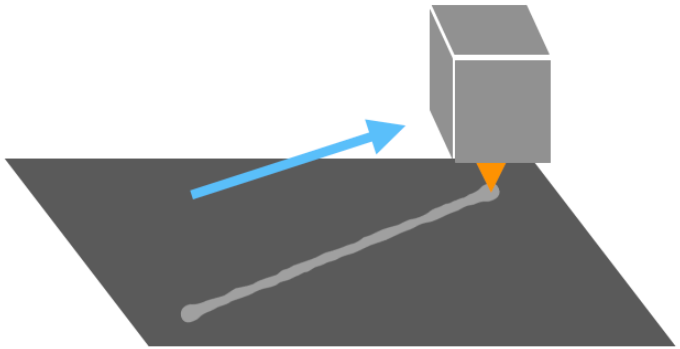


The speed of the print head as it moves from one point to another.

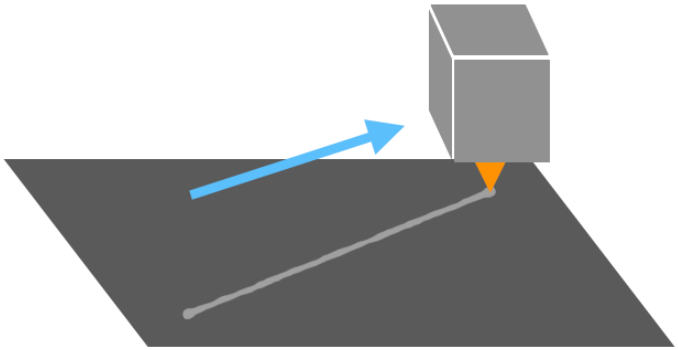
F1000 good starter speed

Extrusion (mm)

```
G01 X100 Y100 E7
```



```
G01 X100 Y100 E3
```

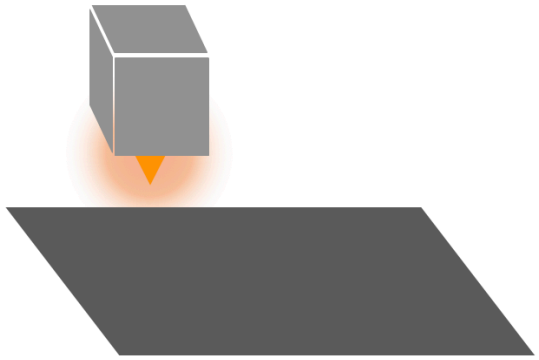


The amount of filament to extrude in mm across specified path.

Temperature

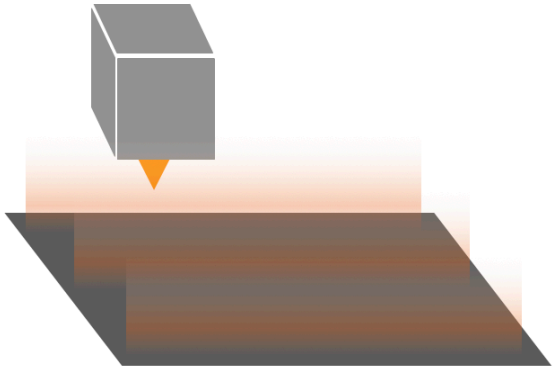
```
M104 S215
M109 S215
```

(Set hotend temperature, and wait)



```
M140 S60
M190 S60
```

(Set bed temperature, and wait)



M104: set extruder temperature, M140: set bed temperature

Other Useful Commands

G28 Home all axes

M0 Pause and wait for user interaction
G04 S100 Pause and wait for 100 ms, then continue

M84 Disable Motors

; Comments are anything on a line that follow a semi-colon

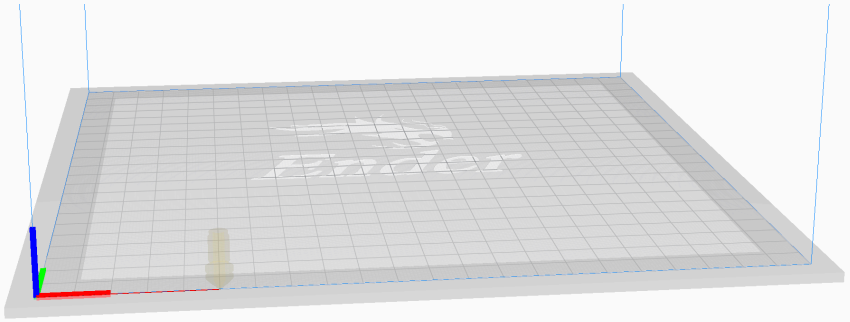
An Example File: Bed Leveling

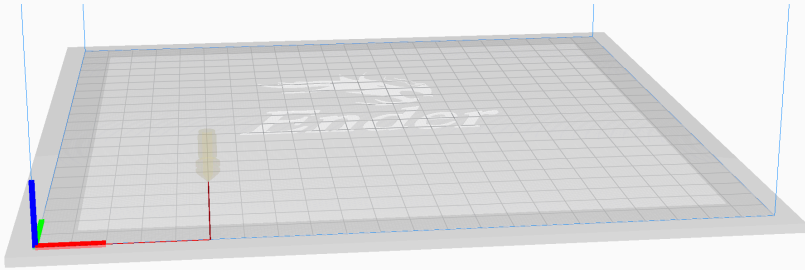
```
G90 ; Absolute mode for position

G28 ; Home all axis
G1 Z5 ; Lift Z axis
G1 X32 Y36 F3000; Move to Position 1
G1 Z0 ; Move Z axis down
M0 ; Pause print

G1 Z10 ; Lift Z axis
G1 X32 Y206 F3000; Move to Position 2
G1 Z0 ; Move Z axis down
M0 ; Pause print

G1 Z5 ; Lift Z axis
G1 X202 Y206 F3000; Move to Position 3
G1 Z0
M0 ; Pause print

G1 Z5 ; Lift Z axis
G1 X202 Y36 F3000; Move to Position 4
G1 Z0
```

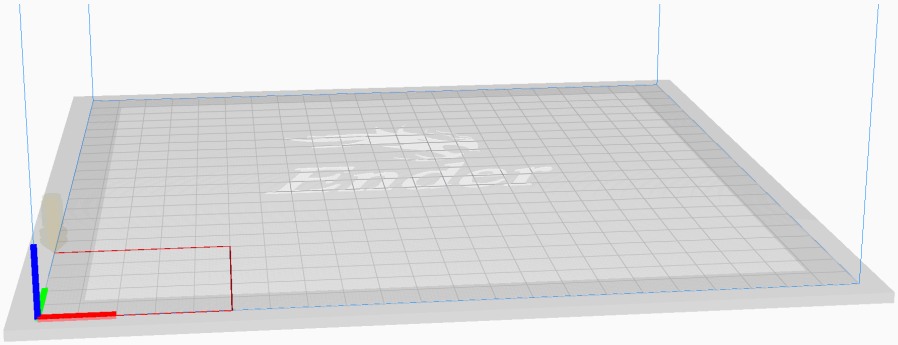
An Example File: Draw a Square

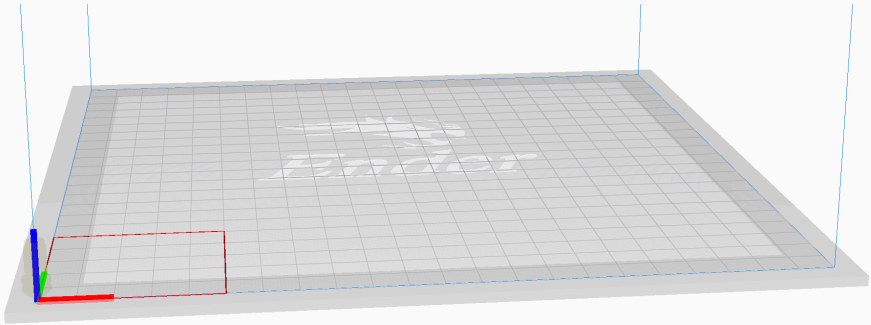
```
G92 E0 ; Reset Extruder
G28 ; Home all axes
M190 S60 ; Set bed temperature and wait
M109 S205 ; Set extruder temperature and wait
G1 F1000 ; Set feedrate (speed) to 1000 mm/s
G91 ; Relative mode for position

; Draw a square
G1 X50.0 Y0.0 Z0.0 E5.0
G1 X0.0 Y50.0 Z0.0 E5.0
G1 X-50.0 Y0.0 Z0.0 E5.0
G1 X-0.0 Y-50.0 Z0.0 E5.0
```

Preview in Cura









questions?

Thank you!

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