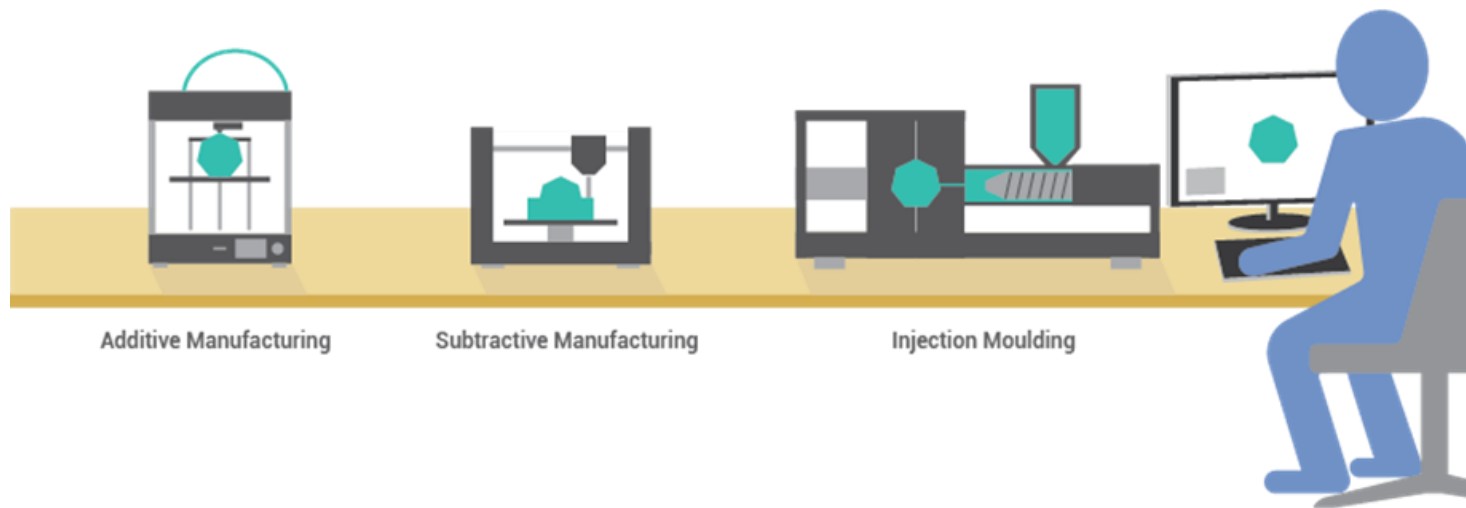# 3D Printing - Overview

MATH 370 – Spring 2019
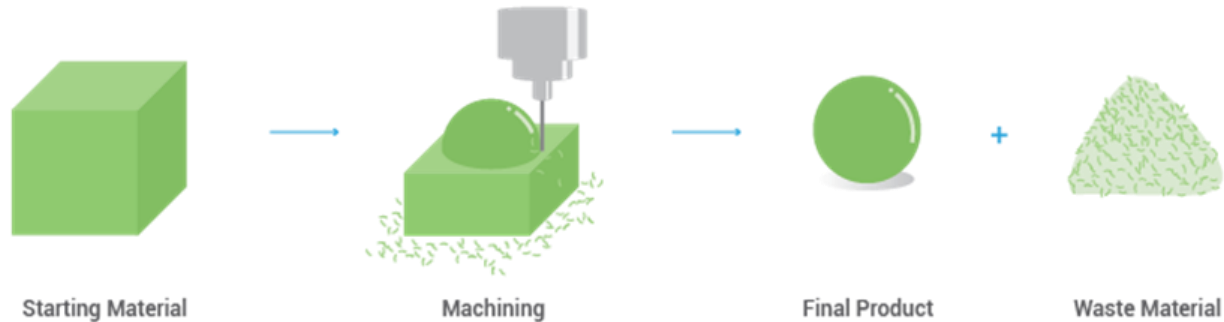
Production of parts falls into three categories:

- Additive Manufacturing (3D Printing)

- Subtractive Manufacturing

- Injection Moulding

Additive Manufacturing   Subtractive Manufacturing   Injection Moulding

Photos: Tinkerine U.

Subtractive Manufacturing

Starting Material   Machining   Final Product   Waste Material
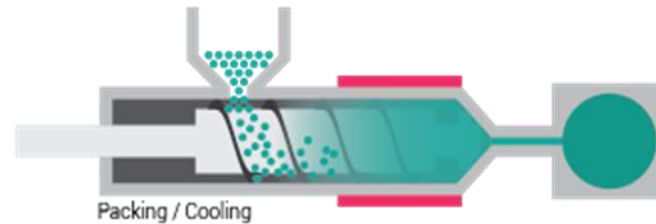
Pros:
- Variety of materials: metal alloy, woods, plastics, foams, wax, etc.
- Interchangeable tooling heads for different purposes

Cons:
- Creates lots of waste material
- High raw material cost

Injection Moulding

Packing / Cooling

Steps:
1. Clamp two halves of mould together.
2. Melt plastic pellets, inject molten plastic into barrel of mould.
3. Apply pressure to ensure all cavities are filled, cool to solidify.
4. Split the mould and remove part.

Pros:
- Can produce high volume of parts per hour
- Low labor costs
- Low waste

Cons:
- Object cannot contain hollow parts
- High initial tooling costs (machine itself and custom mould)

Additive Manufacturing

Starting material (thermoplastic)   Filament melting + deposition   Final product + waste material

Most common method is Fused Filament Fabrication (FFF) – build object layer by layer from the bottom up by heating and extruding thermoplastic filament.

Pros:
- Quickly go from design to physical prototype
- Initial cost for printer and material are low
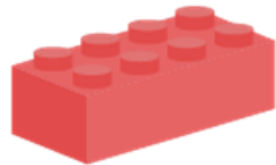- Capable of creating complex shapes

Cons:
- Limited material options
- Size of part limited by size of printer
- Most printed objects are fragile or temperature sensitive

Thermoplastic Filaments

Filaments come in spools and are usually made of PLA (polylactic acid) or ABS (acrylonitrile butadiene styrene).

	ABS	PLA
Primary Benefit	Moving parts, automative parts, electronic housing, toys.	Consumer products, small toys, higher print speed, smoother layers.
Durability	High.	Fair to good.
Flexibility	Low flexibility.	Slight flexibility, brittle.
Food Safe	No.	Refer to manufacturer guideline.
Shrinkage	Yes, require enclosed chamber and/or heated bed.	Minimal shrinkage during printing, less sensitive to cooling.
Health Hazard	Ventilation required. Levels of toxic gas, nanoparticle aerosols.	Non-toxic.

# 3D Printing in Mathematics

Why?

- To create manipulatives and visualizations
- Consolidates math skills to use on real-world problems
- Self-correcting errors – clear when something doesn't work
- 3D technology likely to be highly relevant for future careers
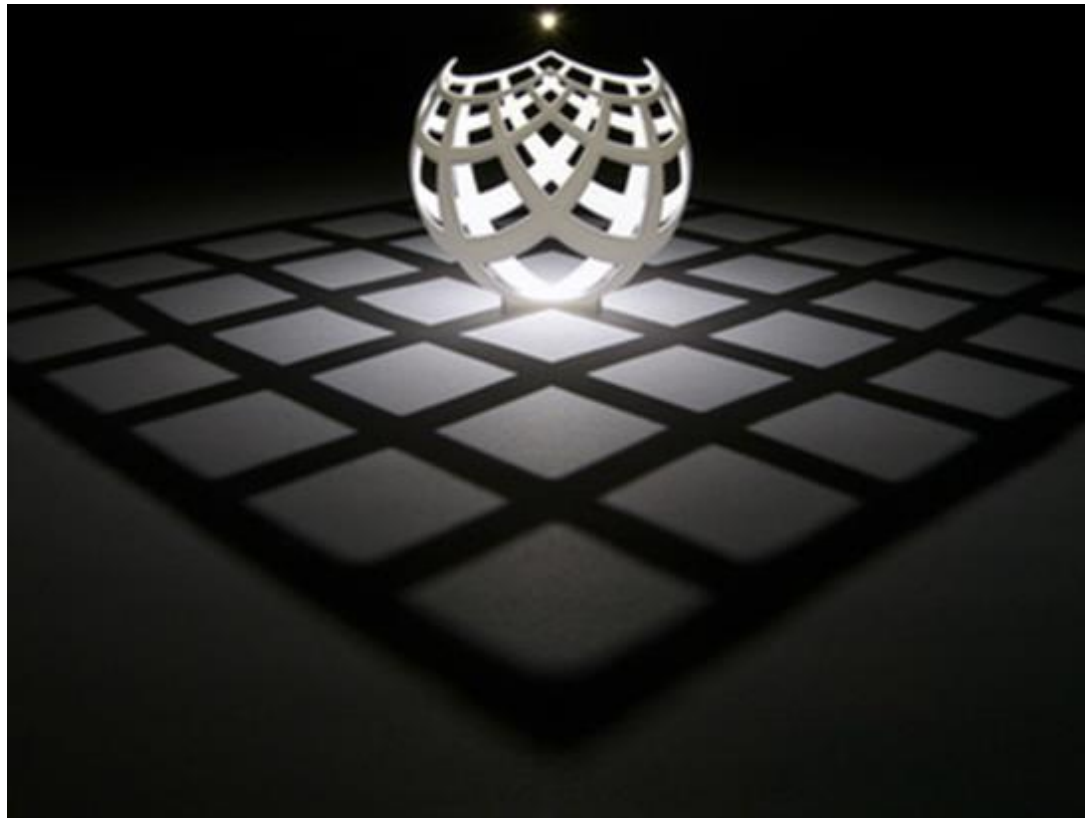
Math Stuff to Print: Symmetry

Photos: Henry Segerman – Oklahoma State University

Math Stuff to Print:
Polyhedra
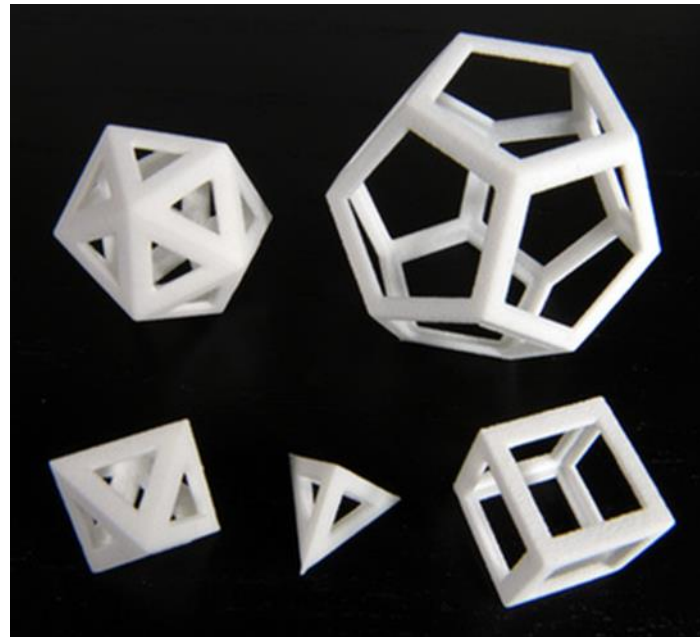
Photos: Henry Segerman – Oklahoma State University

Math Stuff to Print:
Stereographic Projections

Photos: Henry Segerman – Oklahoma State University

Math Stuff to Print:
Surfaces

Photos: Henry Segerman – Oklahoma State University

Math Stuff to Print:
Knots

Photos: Henry Segerman – Oklahoma State University

Math Stuff to Print: Mobiles

Photos: Henry Segerman – Oklahoma State University

Resources

- [Tinkerine U](#) – basic online courses for 3D printing fundamentals

- [Tinkercad](#) – free online CAD (computer-aided design) software for designing models to print

- [Thingiverse](#) – online community for sharing user-created digital design files

- [Robo R2 Support](#) – support documentation for our 3D printer