3D Printing in the FIRST Community

IN FIRST FORUMS

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Hello, I am Rufus Cochran

- 447 student from 2001 to 2006
  - From Co-Operation FIRST to Aim High
- FIRST mentor for a decade+
  - 447, 5010, and 6721
- Rose-Hulman Alumni
  - Computer Engineering
  - Mechatronics
- ~~Controls Engineer at Roche Diabetes Care~~
  - ~~High Speed Vision Systems~~
- Systems Analyst at Roche Diagnostics
  - Predictive Analytics and Artificial Intelligence
- Started a BattleBots team
  - denkbots.com

Overview of Presentation

- Introduction to 3D Printing
- History of 3D Printing
- Why 3D Printing is Important

- The Design Process and 3D Printing
- FIRST and 3D Printing
- Open Hardware and You

Warm Up Questions

- Who has heard 3D Printing?
- Who has a 3D Printer readily available?
- Who owns a 3D Printer?

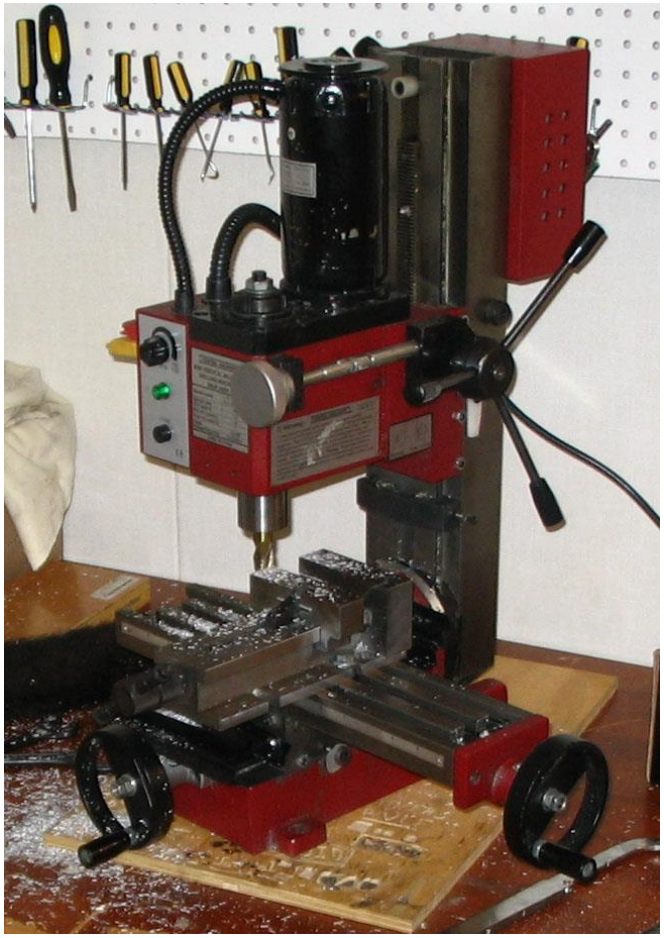
- **Note**: The answers have changed drastically over the last five years.

- Can you think of anything you could have 3D printed on your robot last year?
  - Write ideas down as they come to you, we will share at the end of the show

What is 3D Printing?

Wikipedia

- Additive Manufacturing process for printing a three-dimensional object.
- Production had classically been done by casting, fabrication, stamping, and machining; transforming a mass of raw material into a desired shape layer by layer was associated with processes that removed material (rather than adding it), such as CNC milling.

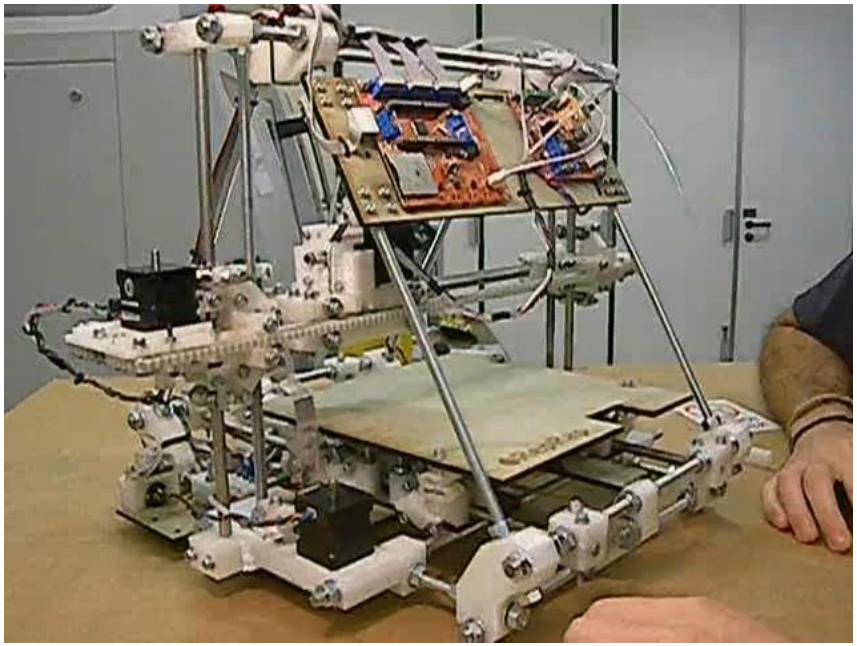


(Not a 3D Printer)

Why is 3D Printing?

Der Spiegel

- "Assembling, screwing together, adhering, welding -- all these processes are rendered obsolete when even the most complex shapes can be produced by a single machine using this casting technique."

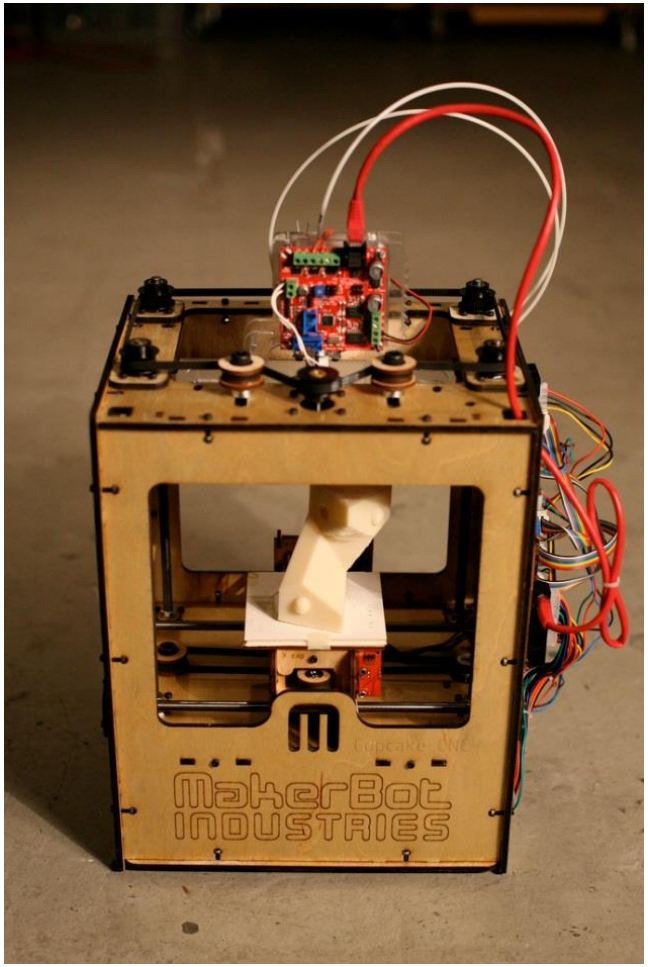


(3D Printer? Or Siege-Engine?)

How does 3D Printing?

Main Types of 3D Printing

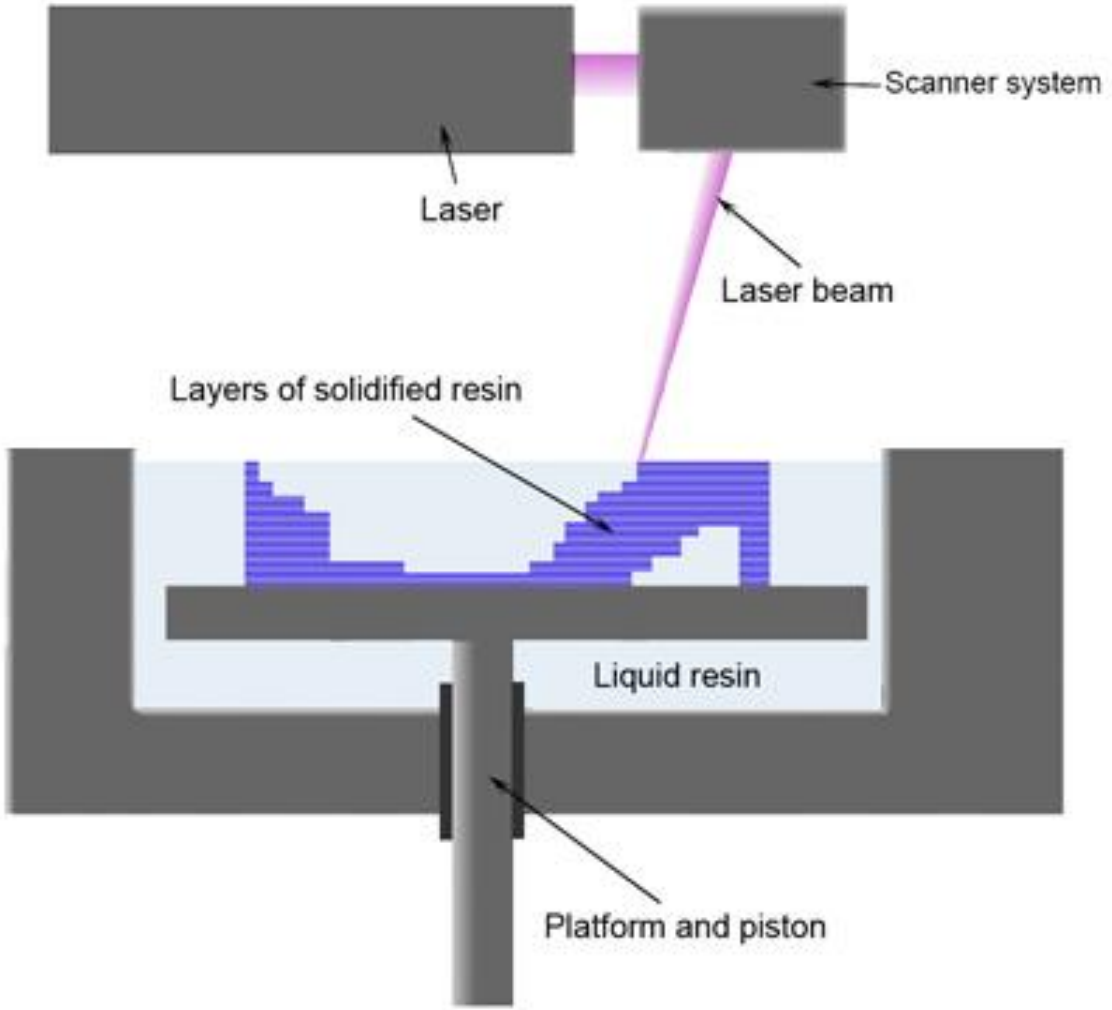
- SLA
  - StereoLithography Apparatus
- SLS
  - Selective Laser Sintering
- FDM
  - Fused Deposition Modeling



(Ok, here is a 3D Printer)

Types of 3D Printing (SLA)

StereoLithography Apparatus



Types of 3D Printing (SLA)

StereoLithography Apparatus

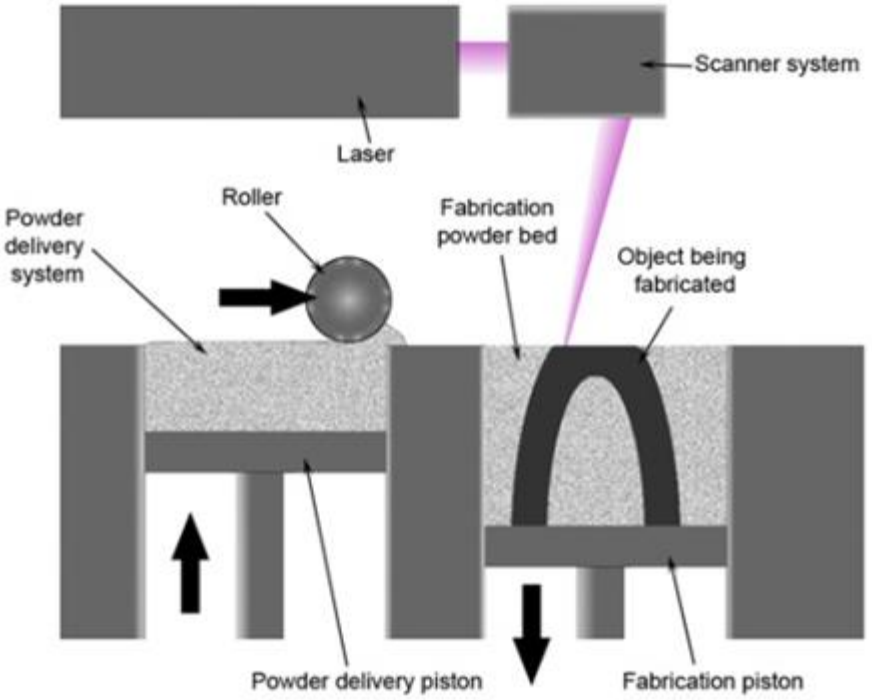
- Creates layers by curing a photo-reactive resin with a UV laser
- Pro:
  - Quick print time
- Con:
  - Brittle prototype
  - Expensive in comparison to FDM.
  - Roughly $149 for 1 liter
    - Roughly the equivalent of 1 kg of FDM
    - https://all3dp.com/fdm-vs-sla/
  - Printers start at $500 (Wanhao Duplicator 7)

SLA
(skip to 1m)

https://youtu.be/enJq2PquuPE

Types of 3D Printing (SLS)

Selective Laser Sintering



Types of 3D Printing (SLS)

Selective Laser Sintering

- Uses a laser to sinter powdered material (typically metal), by aiming laser at points, binding the material together to create a solid structure

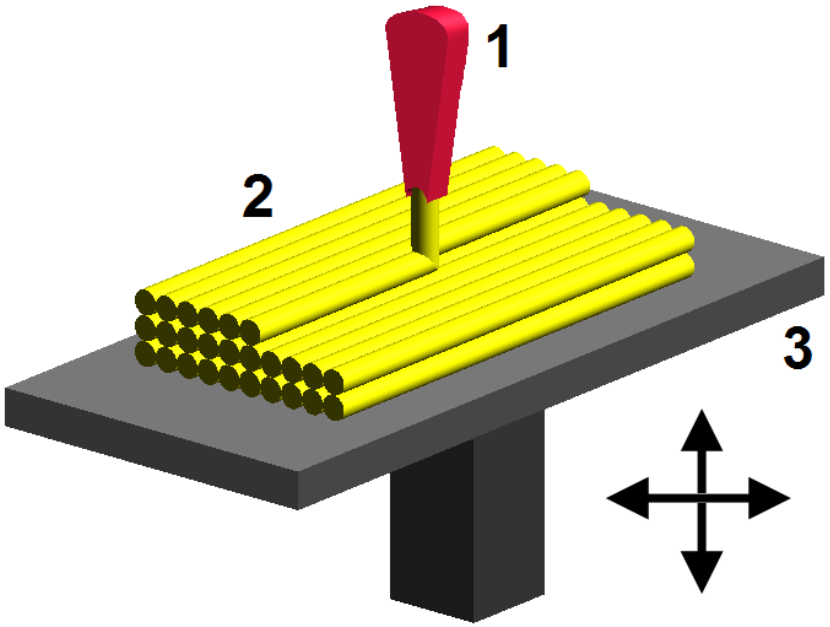
- Pro:
  - Wide range of material
- Con:
  - Longer print time
  - Cheapest current printer is ~$10k

SLS (DMLS)

https://youtu.be/VImKhUD-8hk

Types of 3D Printing (FDM)

Fused deposition modeling



Fused deposition modelling:

1 – Nozzle ejecting molten plastic
2 – Deposited material (modeled part)
3 – Controlled movable table

Types of 3D Printing (FDM)

Fused deposition modeling

- Creates object by laying down material in layers
- Pro:
  - Quick print time
  - Inexpensive
- Con:
  - Bridge material required for hanging edges

FDM

https://youtu.be/vsBVU8PMN_c

History of 3D Printing

Roots of the Technology

- **1972 -** Mitsbushi motors proposes photo-hardened materials be used to produce layered parts
- **1981 -** Kodama publishes first account of working photopolymer rapid prototyping system
- **1984 -** Charles Hull invents stereolithography (SLA)

Origin of the Methods

- **1991 -** Stratasys produces the world's first FDM (fused deposition modelling) machine.
- **1992 -** 3D systems produce the first SLA 3D Printer machine
- **1992 -** DTM produces first SLS (selective laser sintering) machine.

History of 3D Printing

Groundwork for Consumer Applications

- **2000 -** The first 3D inkjet printer
- **2000 -** The first multicolour 3D
- **2001 -** The first desktop 3D printer

The Revolution Begins

- **2005 -** The Reprap project is founded; intended as a democratization of 3D printing
- **2008 -** The first biocompatible FDM material
- **2008 -** The first 3D prosthetic leg is produced
- **2008 -** Makerbot's Thingiverse launches – a website for free 3D model file sharing

History of 3D Printing

Recent Steps Forward

- **2009 -** The first 3D printed blood vessel
- **2011 -** The first 3D printed car
- **2012 -** The first 3D printed jaw is produced
- **2013 -** Cody Wilson of Defense Distributed is asked to remove designs for the world's first 3D printed gun and the domain is seized.

Future of 3D Printing

The Future is Now

- "The future is already here — it's just not very evenly distributed." – William Gibson

- The hype is mostly over
- Many teams have a 3D printer or access to one
  - School district, Sponsor, etc.
- **Why is it still important to focus on 3D printing?**

The Future is Now

Applications in Medicine

- 3D printing sterile surgical tools with PLA at 1/10th the cost of stainless steel instruments
  - University of Arizona
- 3D printed embryonic stem cells
  - Heriot-Watt University in Edinburgh
  - basis for 3D printing organs in future
- 3D printing skin grafts for burn victims
  - James Yoo at Wake Forest Institute
- 3D printed human cell heart patches for heart attack survivors
  - University of Rostock in Germany, Harvard Medical Institute and the University of Sydney

The Future is Now

3D Printing Mice Ovaries at Northwestern University

- Joint project between Fienberg School of Medicine and McCormick School of Engineering
- Goal is to give young female cancer patients ability to have children after treatment
- Engineers and doctors paired up
- Success in mice with 3d-printed ovaries giving birth to healthy mice pups

The Future is Now

3D Printing Mice Ovaries at Northwestern University

video

The Future is Now

Wearable Art

- Dita Von Teese's 3D printed gown
  - first of its kind
  - designed by Michael Schmidt and 3D modeled by architect Francis Bitonti to be 3D
  - printed in Nylon by Shapeways
  - fully articulated gown based on the Fibonacci sequence
  - assembled from 17 pieces, dyed black, lacquered and adorned with over 13,000 Swarovski crystals
- Aura Pendant
  - personalized jewelry
  - marketing genius

The Future is Now

Aura Pendant

video

The Future is Now

Masks for Corpses, because Halloween

- Ministry of Civil Affairs in China
- Reconstruct faces for people that have died in traumatic accidents causing facial deformities
- Babaoshan Funeral Home in Beijing has become the first in the province to use 3D printing to speed up facial reconstruction on corpses
- Instead a mortician spending a week on facial reconstruction, a mask can be 3d printed in 12 hours

The Future is Now

Apis Cor 3D Printer

- invented by Russian engineer Nikia Chen Yun Tai
  - 16.4 ft by 5 ft footprint
  - Weighs 2.5 tonnes
  - Assembled in 30 minutes
  - Maximum printing zone 630 sq ft
  - 38 square meter bungalow in Russia
- Russia's first 3d printed home
  - 24 hours
  - Cost $10,134
- Challenges
  - Startup costs of 3d printer, temperature of concrete
- Applications
  - Peace Corp, Doctors Without Borders, FEMA, Mars - no, not yet, we're almost there

The Future is Now

Apis Cor 3D Printer

video

The Future is Now

3D printed house on Mars (sort of)

- SJ Keating, JCC Leland, adn N Oxman at MIT
- "Digital Construction Platform"
- Team used certain requirements to make it practical (requirements based design!!!)
- Robot has to use materials found on site - like ice or dirt
  - This makes it useful in remote areas, LIKE MARS
- Robot has to be moved by people
- Robot has to have a long arm to lift heavy things
- Has to perform finely detailed tasks
- Has to be able to integrate into existing construction practices and use existing materials
- Robot is essentially a giant hydraulic arm on caterpillar treads

The Future is Now

3D printed house on Mars (sort of)

- On the end of the arm is a one-fingered hand attached, which can move more freely and is responsible for fine-motor tasks
- Can be fitted with a range of different tools, including a foam insulation gun, a welding attachment, a "thermoplastic extruder" that squirts out melted plastic, a glorified squirt gun, and even a simple bucket
- Equipped it with solar panels and battery packs to power an electrical drive system
- Weighs 8100 lbs
- Initial costs $250,000
- Used expanding foam that sets in 30 seconds
- Final structure 12 ft high x 50 ft diameter
- 13 hours to build largest 3d printed structure ever

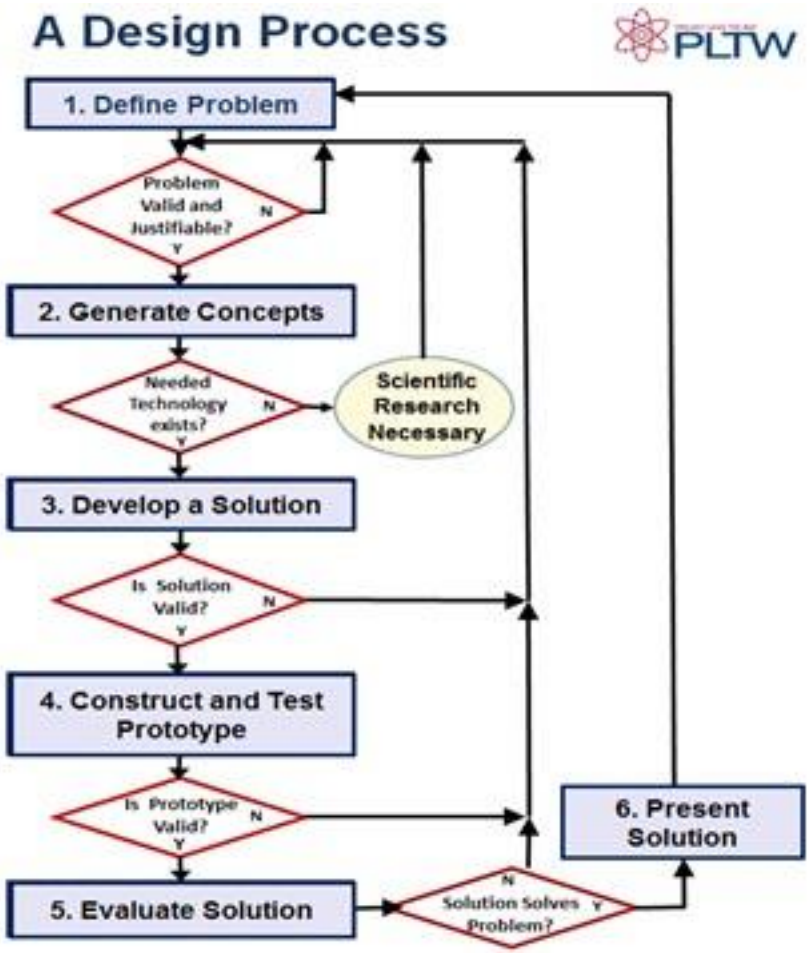
Why 3D Printing?

- Many areas of expertise have to work together for 3D printing to happen and to expand
  - Material Science
  - Mechanical Engineering
  - Electrical Engineering
  - Programming
  - Mechatronics
  - Drafting/3D Modeling
  - Biomedical Engineering
- Multi-disciplinary and cross-functional teamwork
  - Like FIRST!

But what can 3D Printing do for me?

The Design Process

- The most expensive and time consuming part of the design process, is prototyping
- Students can see their ideas almost instantly materialize in front of them, revise, and retry



But I bet it costs over $9,000?

- $20 for 1kg spool of PLA
- $350 to $600 for very capable 3D Printers
- Monoprice MP Select Mini 3D printer V2, a $219.99 fully assembled 3D printer. (Build area only 4.7" cubed)
- Doesn't your school already have a 3D Printer?

printrbot simple

(Assembled for $599)

But I can't afford/use that CAD program.

- What are the benefits of using CAD?
- There are several free CAD softwares
- Does your school PLTW?
  - Your kids might already know, and have access to, CAD software

- hackaday.com has free tutorials for:
  - OpenSCAD
  - AutoCAD
  - Blender
  - SketchUp
  - Autodesk 123D
  - FreeCAD
  - Solidworks
- Autodesk Fusion 360

https://denkbots.com/links/links_prototyping/

Intro 3D Printing exercises for teams

- Have students design a team keychain
- Print out all the different designs
- Figure out what doesn't work, why it doesn't work, and iterate the designs
- Students make giveaways for competition
- Students learn how to design parts to be 3D printed
- Team learns strengths and limitations of 3D parts


Think Twice
Instant
Draw a card.
Flashback 2 (You may cast this card from your graveyard for its flashback cost. Then exile it.)
"Either I know just the spell I need, or I'm about to."
Anthony Francisco
™ & © 1995–2011 Wizards of the Coast LLC 83/264

So how do we leverage this technology to improve the FIRST community?

OPEN HARDWARE

- Remember thingiverse?
- We build an open repository of robotics (FRC, FTC, botball, VEX, etc.) focused parts

COMPETITION

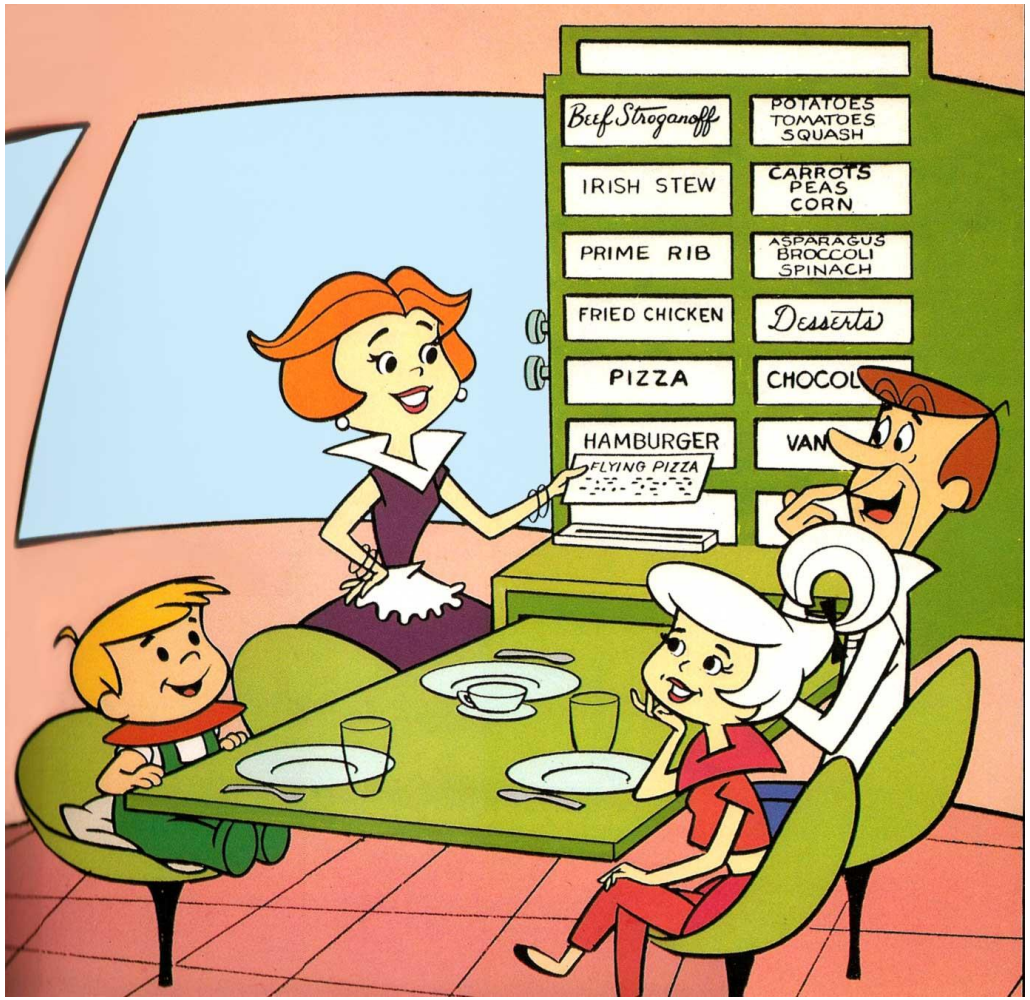
- If there was an award/prize for 3D printed parts at the district events, would you apply?
- If all of the parts submitted went into the database above for everyone to use, would you use it?

Some Notes

- AndyMark has 3D Parts
- A team 3D printed their whole chassis
- What if you downloaded your kit of parts?
- Any part made in CAD software can be exported to an STL file
- Then software like Cura and Slic3r can turn it into reprap instructions for any 3D printer
- **Who has actually used that 3D Printing Voucher in you KOP?**

Remember those parts you wrote down?

- Share your ideas
- What if you had designed and shared those parts?
- What if other teams had already designed and shared those parts?



Questions?

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Presentation

at denkbots.com