

# 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
- Started a BattleBots team
  - [denkbots.com](http://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

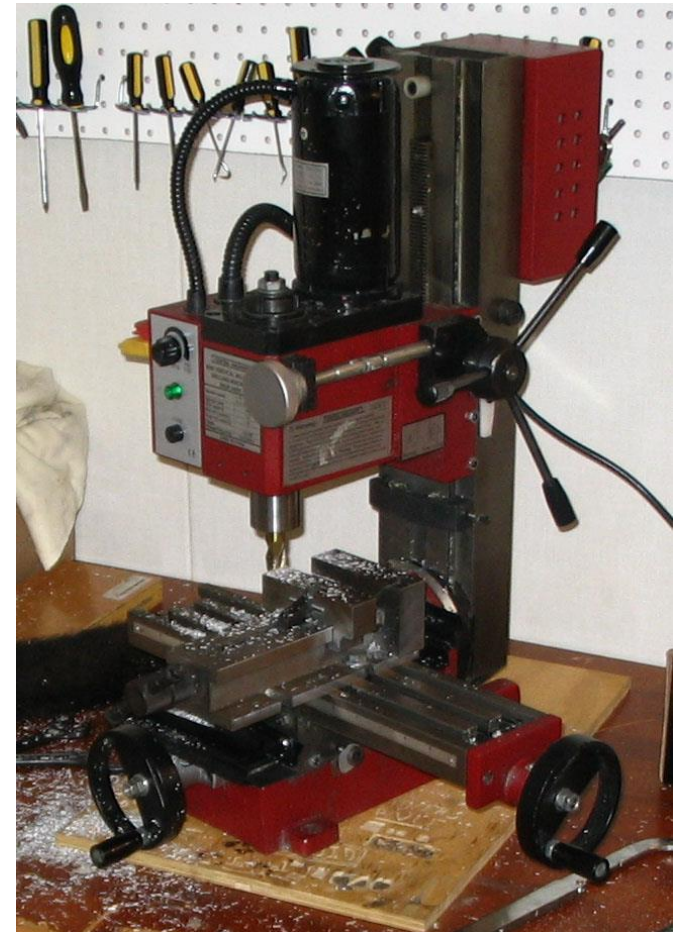
## Warm Up Questions

- Who has heard of 3D Printing?
- Who has a 3D Printer readily available?
- Who owns a 3D Printer?
- **Note**: The answers have changed drastically over the last four 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.

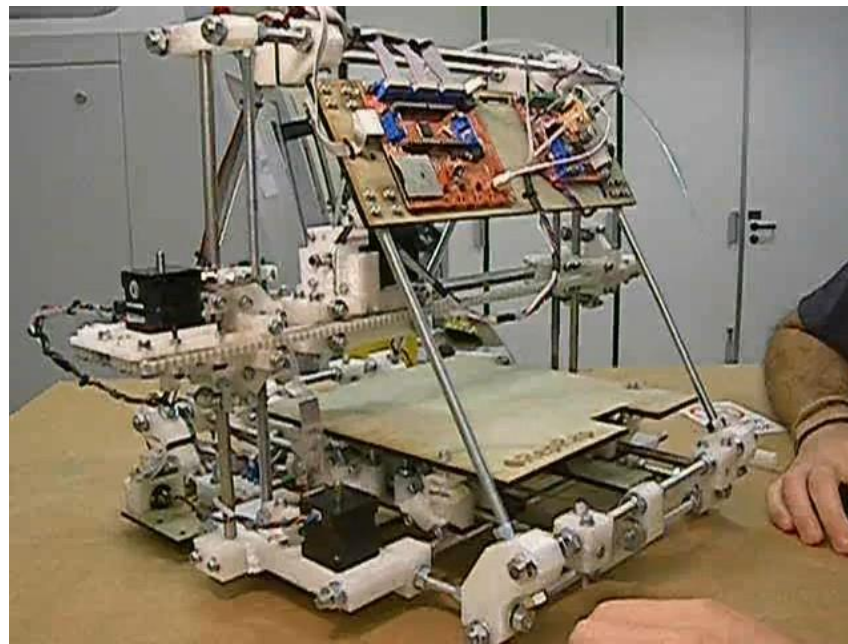


(Not a 3D Printer)

# 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."

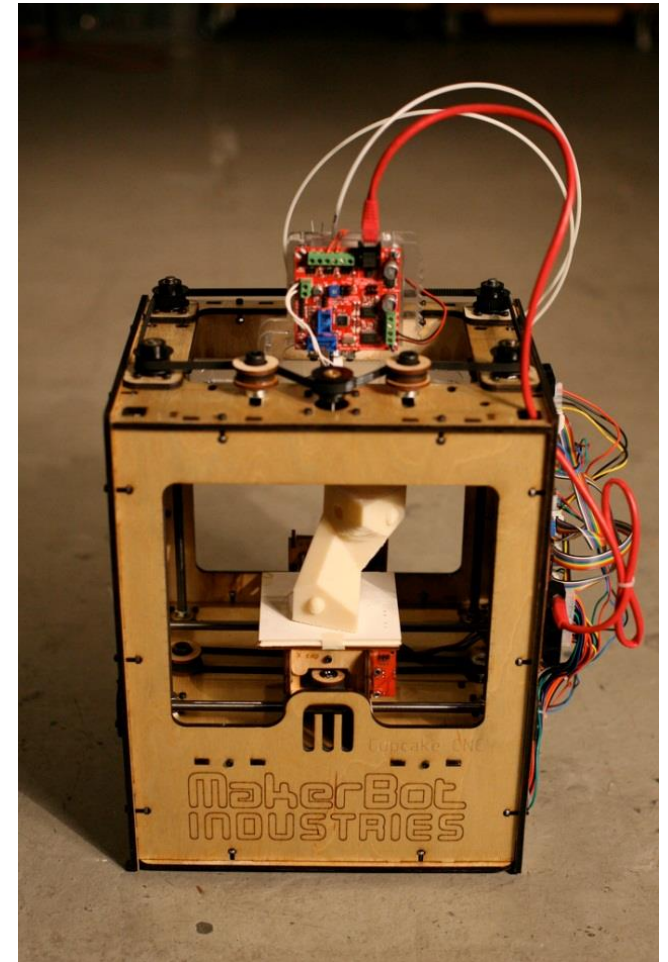


(3D Printer? Or Siege-Engine?)

# How does 3D Printing?

## Main Types of 3D Printing

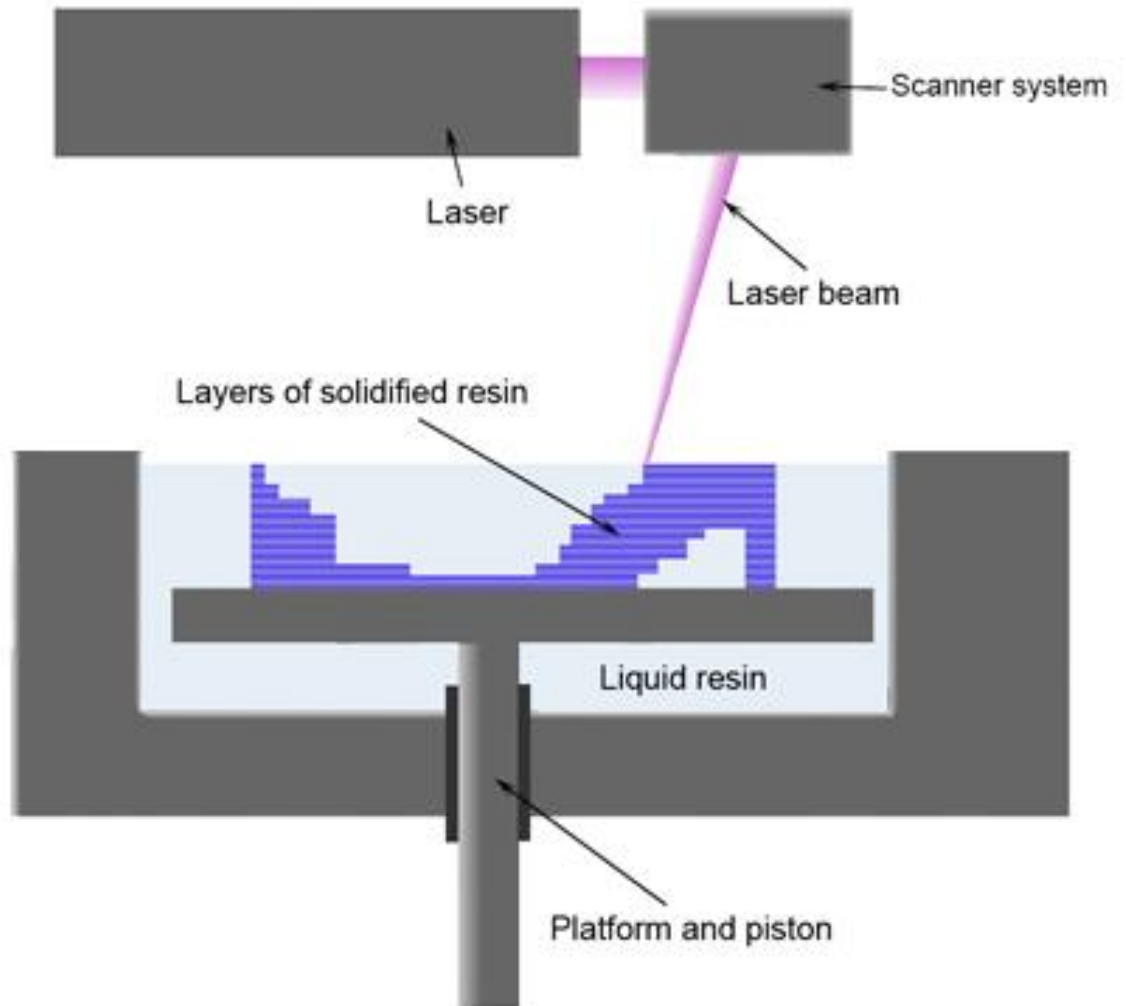
- SLA
  - StereoLithography Apparatus
- SLS
  - Selective Laser Sintering
- FDM
  - Fused Deposition Modeling



(Ok, here is a 3D Printer)

# Types of 3D Printing (SLA)

## StereoLithography Apparatus





# Types of 3D Printing (SLA)

## StereoLithography Apparatus

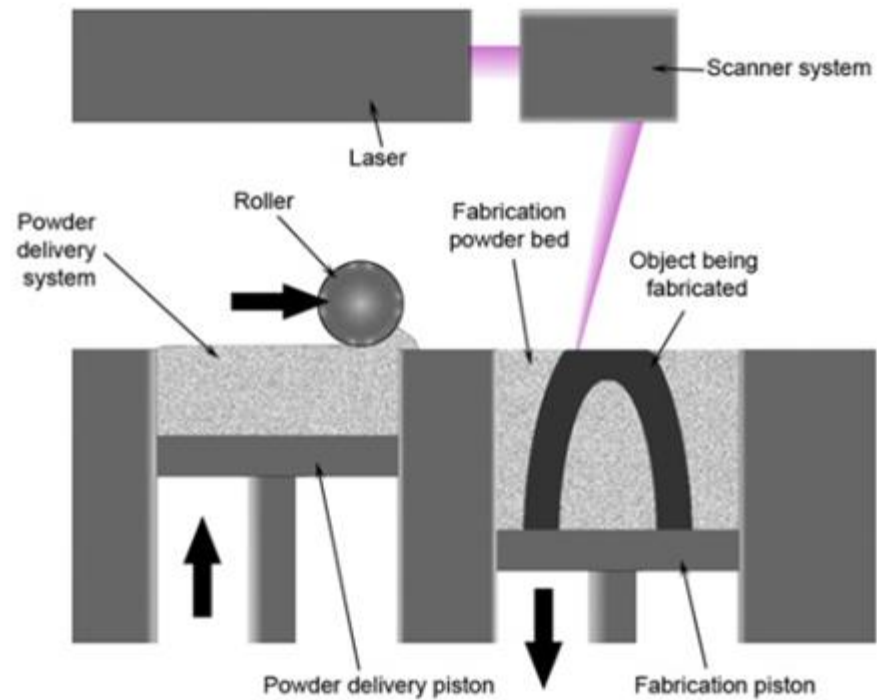
- Creates layers by curing a photo-reactive resin with a UV laser
- Pro:
  - Quick print time
- Con:
  - Brittle prototype
  - Expensive in comparison to FDM.
  - Roughly \$149 for 1 liter
    - Roughly the equivalent of 1 kg of FDM
    - <https://all3dp.com/fdm-vs-sla/>
  - Printers start at \$500 (Wanhao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

SLA  
(skip to 1m)

<https://youtu.be/enJqzPquuPE>

# Types of 3D Printing (SLS)

## Selective Laser Sintering



# Types of 3D Printing (SLS)

## Selective Laser Sintering

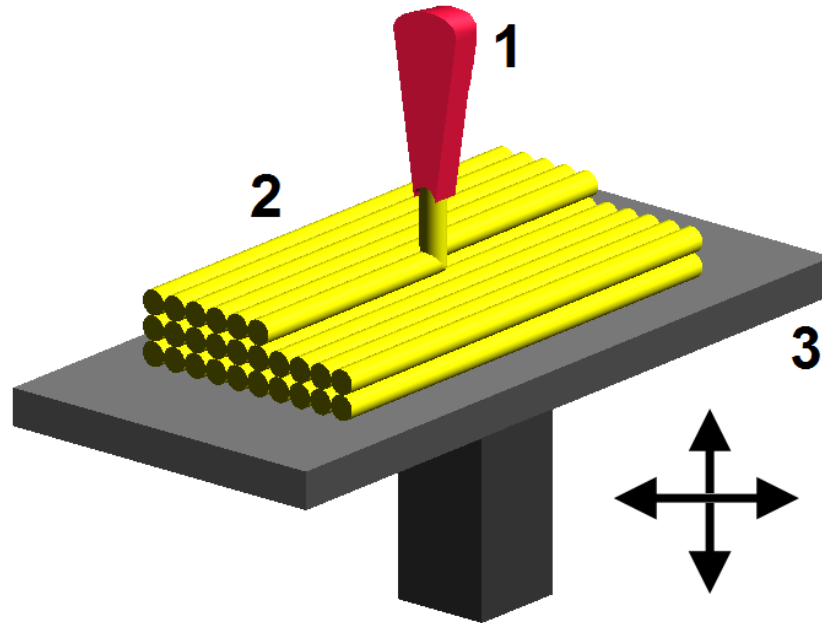
- Uses a laser to sinter powdered material (typically metal), by aiming laser at points, binding the material together to create a solid structure
- Pro:
  - Wide range of material
- Con:
  - Longer print time
  - Cheapest current printer is ~\$10k

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](https://youtu.be/vsBVU8PMN_c)



# History of 3D Printing

## Roots of the Technology

- **1972** - Mitsubishi 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 initial excitement has decreased significantly
- 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

# 3D Printing Sterile Surgical Tools

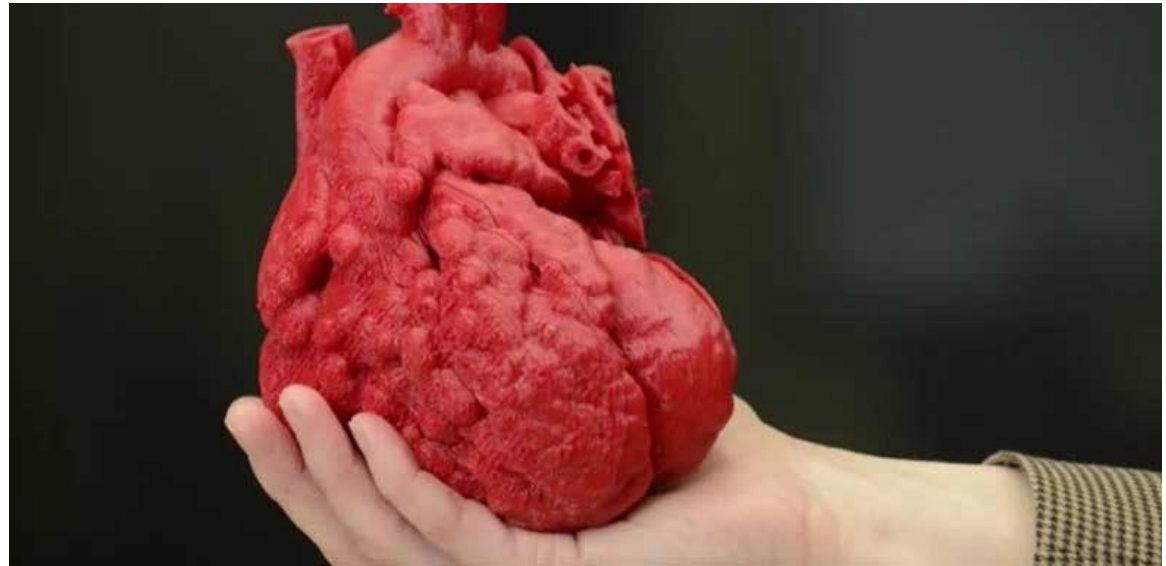


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# 3D Printed Human Cell Heart Patches





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

[https://youtu.be/\\_5whpjIPO6Q](https://youtu.be/_5whpjIPO6Q)

# 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

Dita Von  
Teese's 3D  
Printed  
Gown



# The Future is Now

## Wearable Art

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The Future  
is Now

Aura Pendant

[https://youtu.be/h\\_OXo6zZer4](https://youtu.be/h_OXo6zZer4)

# 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

# Masks for Corpses





# 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
  - 409 sq ft 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

<https://youtu.be/8z-iebHRxJk>

# The Future is Now

## 3D printed house on Mars (sort of)

- Team 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
- Design Requirements
  - 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

The Future  
is Now

3D printed house on Mars (sort of)

[https://youtu.be/8zt\\_3Gs1ksg](https://youtu.be/8zt_3Gs1ksg)

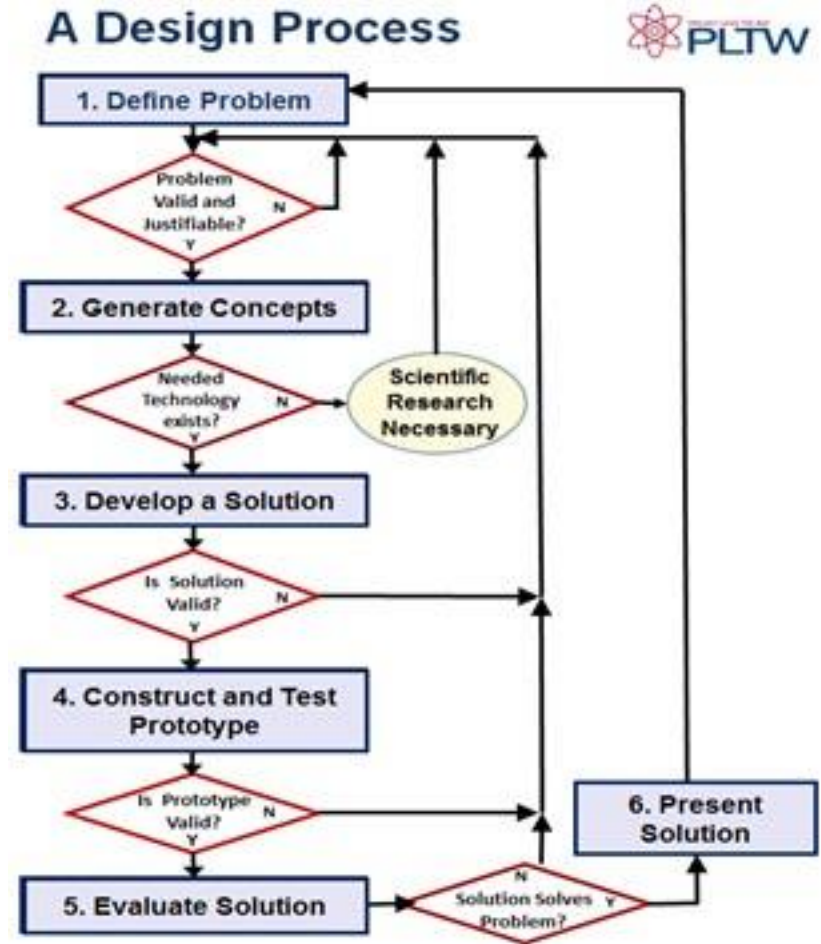
# Why 3D Printing?

- 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/](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

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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

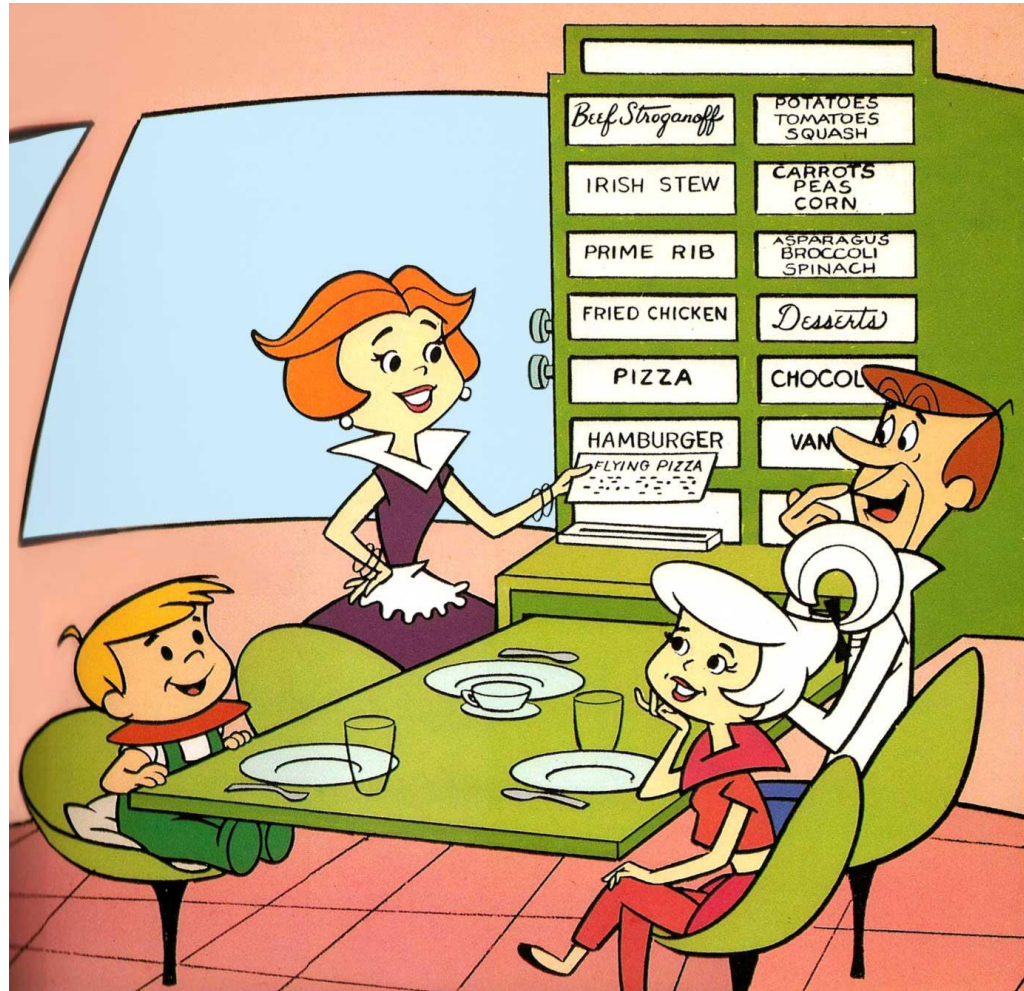
- AndyMark has 3D Parts
- A team 3D printed their whole chassis
- What if you downloaded your kit of parts?
- Any part made in CAD software can be exported to an STL file
- Then software like Cura and Slic3r can turn it into rewrap instructions for any 3D printer





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?



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Presentation

at [denkbots.com](http://denkbots.com)

Questions?

