DIY 3D Printing
Hardware & Software

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softsolder.com
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ACM Poughkeepsie Chapter
May 2012
Upcoming Events

- Tchotchkes!
- 3D Printer Hardware Overview
- 3D Printer Action Movie
- Solid Modeling: OpenSCAD
- CAD & CAM Process
  - Design → CSG → Plastic
- 3D Modeling Gotchas
- Why I Have a 3D Printer
- Q&A + Touchy-Feely
Tchotchkes

- Simple examples
  - Quick printing
  - Mixed plastic colors
- These are test pieces
  - Numbers = parameters
  - Some **All** have defects!
  - Understand the limits
- Share nicely...
Threads

- Object “Skirt”
- Test/verify extrusion
  - 0.33 or 0.25 mm
  - ±0.1 mm or so
  - Width = 2 x thickness
- All layers identical
  - Depends on software
- Data! Data! Data!
DIY 3D Printing

- Building things with a hot-melt glue gun
  - A very small glue gun: nozzle 0.2 to 0.6 mm dia
  - A very hot glue gun: 190 to 230 °C = 350 to 450 °F

http://www.thingiverse.com/thing:2064
Cartesian Coordinates

- **Z Axis**
  - +Up - Down
- **X Axis**
  - +Right - Left
- **Y Axis**
  - +Back - Front
- **A Axis**
  - Filament drive motor
- **Nozzle vs. platform?**

http://www.thingiverse.com/thing:2064

https://en.wikipedia.org/wiki/Cartesian_coordinates
3D Printing Mechanics

- Z Axis stage
  - Filament drive = A Axis
  - Extruder “Hot End”
  - Nozzle
- X and Y Axis Stages
  - Build platform (heat?)
  - Leveling
- Build Chamber
  - LED strip lighting!
- Coordinate Origin?
Thermal Isolation

Molten plastic vs. plastic structure...

http://softsolder.com/2011/02/27/mk5-extruder-head-external-temperatures/
RepRap Prusa Mendel

http://reprap.org/wiki/RepRap_Options
NopHead Mendel90

http://hydraraptor.blogspot.com/2011/12/mendel90.html
Printrbot

http://printrbot.com/
PrintrBot Kickstarter

Backers: 1,808

Goal: $25,000

Pledged: $830,827

http://www.kickstarter.com/projects/printrbot/printrbot-your-first-3d-printer
Makerbot Replicator

http://store.makerbot.com/replicator-404.html
Makergear M2

http://www.makergear.com/products/m-series-3d-printers
3D Systems Cubify

http://cubify.com
3D Printing Up Close

Tux Cookie Cutter

The Movie

Solid Model

- Define **shape & size**
- Geometric primitives
  - Cube, cylinder, sphere
- Transform objects
  - Scale, move ...
- Boolean combinations
  - Union, difference ...
- Draw it or program it?
  - Art vs. Engineering

http://softsolder.com/2012/04/10/kindle-fire-power-button-protector/
union() {
    translate([[PlugOffset,0,0]])
        cylinder(r=PlugDia/2,
            h=(PlugLength + PlateThick),$fn=8);
    translate([[0,USBOffset,(PlateThick + USBLength)/2]])
        cube([[USBWidth,USBThick,(PlateThick + USBLength)],[
            center=true]);

difference() {
    translate([[0,0,PlateThick/2]])
        roundedBox([[PlateLength,PlateWidth,PlateThick],
            PlateRadius,true,$fn=4*4]);
    translate([[ButtonOffset,0,-Protrusion]])
        rotate(360/(2*8))
            PolyCyl(ButtonDia,(PlateThick + 2*Protrusion));
}
}
Amateur Radio GPS+Voice

Acrylic sheet machined on my Sherline CNC mill

http://softsolder.com/2010/06/17/gps-audio-interface-for-icom-z-1a-ht/
Subtractive Machining

Sherline CNC milling machine running LinuxCNC (née EMC2)

Why I Have a 3D Printer

http://softsolder.com/2012/03/01/gpsvoice-interface-for-wouxun-kg-uv3d-brassboard/
http://softsolder.com/2011/10/05/gpsvoice-interface-for-wouxun-kg-uv3d-circuit-hackage/
How It Starts

http://softsolder.com/2009/01/01/geek-scratch-paper/
CAD Solid Model
3D Printed Parts
Base Plate - Solid Model
Base Plate - Solid Plastic
CAD = Numbers!

http://softsolder.com/2012/04/05/kg-uv3d-gpsvoice-battery-pack-alignment-lugs/
Constructive Solid Geometry
CSG = By the Numbers
Negative Volumes
Constructing Solid Plastic

http://softsolder.com/2012/04/04/kg-uv3d-gpsvoice-interface-battery-case-latch/
CAD = Design

- Measurements / Style
- Geometric Shapes
  - Min/max width & thickness
- Support structures
  - Auto vs. manual
- Printing orientation
  - Surface finish!
  - Multiple parts per run?
CAM = Manufacturing Process

- Given valid CAD geometry
- Slice into layers
  - Thickness & width
  - Infill density
  - Hole size adjustment?
- Emit G-Code program
  - Which RS-274 dialect?
  - Speed(s) & acceleration
  - Temperature(s)
Printed Plastic!
“Given **Valid CAD Geometry**…”

Gray face = external surface of object
Purple face = adjacent to subtracted object

What’s Wrong With This Picture?
Solid Model $\rightarrow$ G-Code

Geometric Requirements

- Closed surface
  - “Watertight” objects
- Consistent Normals
  - All aimed outward
- 2-Manifold
  - Exactly 2 faces / edge

http://reprap.org/wiki/Separate_page_on_the_question
Exactly Two Faces / Edge

What’s Wrong With This Picture?

- Closed surface
- Consistent Normals
- Easy to see?
  - In this model...
  - Book version is OK
- CSG = 3D volumes
- Mesh = 2D surfaces

Beginning Google SketchUp for 3D Printing http://www.apress.com/9781430233619
http://reprap.org/wiki/Sketchup_Modeling_for_3d_Printing
http://reprap.org/wiki/Art_of_illusion
SketchUp is not the same as Computer Assisted Design or CAD. CAD applications are designed specifically for representing concrete information, while SketchUp is for exploration and design of concepts and ideas (though you are not prohibited from designing models that are as concrete or accurate as those designed in CAD).

[That's my emphasis...]
Mostly, It Just Works

- Feature size
  - $\geq 2 \times$ Thread Width
  - $n \times$ Thread Thickness
- Aspect ratio
  - Squat = good
- Build plate adhesion
  - Square = good
- *Always* preview G-Code
  - Catch problems early!

http://softsolder.com/2012/04/10/kindle-fire-power-button-protector/
If You Want It ...

... And You Can Draw It ...

- Multiple components
  - Fasteners?
  - Rotating joints
  - Adhesives
- Design style
  - Rounded edges!
- Projecting snout
  - Can’t be built that way
  - Can’t be reoriented

... You Can Probably Build It
DIY Support

Canon SX230HS Lens Cap

Replacement Clamp Handle

Dishwasher Rack Protector

Superflash Mount
Support Structures
Why I Have a DIY 3D Printer

Digital Caliper Repair

Thing-O-Matic X Axis Rod Follower
Why I Have a DIY 3D Printer

Tour Easy Superflash Mount

Tour Easy Zzipper Fairing Mount
Why I Have a DIY 3D Printer

Camera Macro Adapter and Microscope Mount
Microscope LED Ring Illuminator
Should *You* Have A DIY 3D Printer?

- Are you an engineer?
  - Do you know one?
- Willing to **DIY**?
  - Have parts / tools?
  - Have time?
  - Willing to learn?
- Imperfections OK?
  - Even ugly ones?
- Go for it!

Q&A + Touchy-Feely

- Ask questions
- Mill around
- Examine stuff
- *Ask questions*
- Iterate ...
Other Places To Go

- Wikipedia: 3D Printing
- RepRap: Useful Software List
- OpenSCAD: 3D CAD for Programmers
- Slic3r: STL-to-GCODE translator / slicer
- Pronterface: GCODE-to-printer interface
- Thingiverse: A Universe of Things
- Search the InterWebs for the obvious terms
- Click on the links in the PDF version!
Copyright-ish Stuff

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The rest is my own work

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Ed Nisley

Say “NISS-lee”, although we're on the half-essed branch of the tree

Engineer (ex PE), Hardware Hacker, Programmer, Author

The Embedded PC's ISAÂ Bus:Â Firmware, Gadgets, Practical Tricks

Circuit Cellar www.circuitcellar.com
  Firmware Furnace (1988-1996) - Nasty, grubby hardware bashing
  Above the Ground Plane (2001 ...) - Analog and RF stuff

Digital Machinist www.homeshopmachinist.net
  Along the G-Code Way (2008 ...) - G-Code, math, 3D printing

Dr. Dobb’s Journal www.ddj.com
  Embedded Space (2001-2006) - All things embedded
  Nisley’s Notebook (2006-2007) - Hardware & software collisions

The Smell of Molten Projects in the Morning
softsolder.com

September 1962
If you can’t read this then make a new friend ‘way up front