3D Printing for Hams

Jim Brown, W0RLD
Kyle Bandy, KC9GLR

Introduction - Show and Tell

What can 3-D printing do for you as a ham?

- Containers for DIY projects
- Antenna anchors (ends and middle)
- Radial clips for visibility
- Custom feedline connectors

Jim

Automatic Satellite Tracker

- Case for dual-axis motors, Arduino, motor controller and compass
- Tripod mount for case
- Attachment device for boom counter weight

Jim

Coax Connection for Magnetic Loop

- Coax connector for two-inch mag loop
- Inner loop connector
- Remote tuner for mag loop
- Car Mount

Jim

Two Meter Yagi

- Connection to boom
- Elements attach and detach via magnets

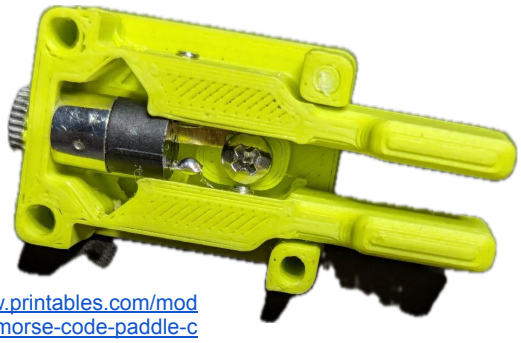
Jim

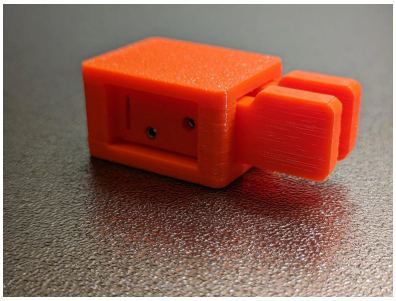
Hold Down for Vertical Antenna

- Additional supports for tripod using nails and 3-D parts
- Visible flags for radials

Jim

CW Key





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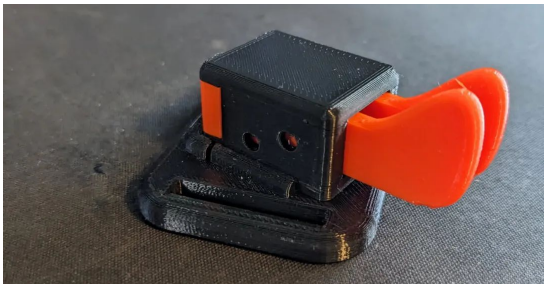
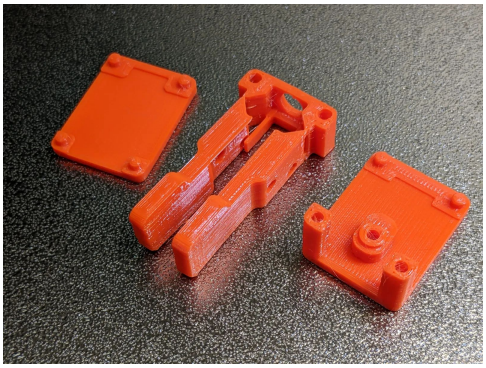




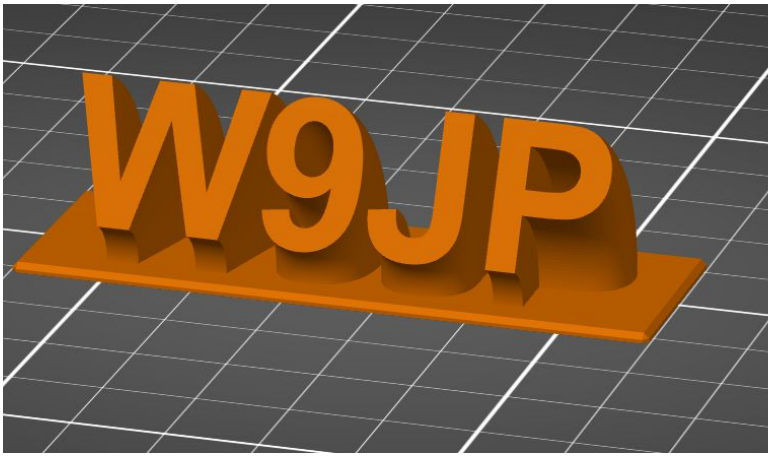
Kyle

3D-printed parts shown at bottom-left

Finished product at top-right

Modified version at bottom-left
–custom paddle shape
–attached to an angled leg strap to secure the key
—--great example of how easy it is to customize 3d-printed components to fit your exact needs

Call Sign Art



Print in-progress!

https://www.thingiverse.com/thing:3045130

Kyle

“Dog Bone” Insulators

design by W7SLM

https://www.thingiverse.com/thing:3557913/files

Kyle

Coax “Stay”

design by KC9GLR

Later: Design demo

Kyle

What Do I Need to Know?

Essential Equipment

- **3D Printer** - FDM printers (like Ender 3, Prusa i3) are beginner-friendly and affordable
- **Filament** - Start with PLA plastic (easiest to work with, minimal warping)
- **3D Models** - Download from Thingiverse, Printables, or MyMiniFactory, or create your own
- **Slicing Software** - Free options like Cura, PrusaSlicer, Orca or Bambu Studio to convert 3D models to printer instructions

Kyle

Roadmap of the remainder of the presentation

Obviously you'll need a 3D Printer–or at least access to one. We will focus on **Fused Deposition Modeling** printers here. They're the most affordable and most common. We aren't going to touch on other 3D Printing technologies like Resin or Selective Laser Sintering.

Once you have a printer, you'll need filament to actually print things with. Think of it as ink or toner for a 2D printer. We'll talk about some of the different filament materials out there.

With a printer and filament, you need something to actually print. Unlike a 2D printer, it's not quite as easy as browsing the web and printing a webpage or downloading and printing a PDF document. First, you'll need to find a 3D model that you actually want to print. (These are typically .STL files.) Or you can design a model yourself. (I'll give a live demonstration of that.)

With a printer, filament, and 3D model, now you need software which can translate the 3D models into machine-level code (called **G-code**) that the 3D printer can understand. We call that software **the slicer** because it "slices" the 3D model into layers that will be printed. Think of the 3D model as computer code, and the slicer as the compiler for that code. We'll cover a few slicer options later in the presentation.

What Do I Need to Know?

Key Skills to Learn

• **Bed Leveling** - Ensures first layer adheres properly (most critical skill for success)
• **Basic Maintenance** - Cleaning nozzles, replacing filament, calibrating extruder
• **Slicing Settings** - Layer height, infill percentage, print speed, and support structures
• **Troubleshooting** - Fixing common issues like warping, stringing, and layer adhesion problems

What Do I Need to Know?

Getting Started Steps

• **Start Simple** - Begin with basic prints like calibration cubes and simple objects
• **Learn Your Machine** - Read manual thoroughly and understand your printer's specific requirements
• **Join Communities** - Reddit (r/3Dprinting), Discord servers, and local maker spaces provide valuable support
• **Practice Regularly** - Consistency helps you recognize patterns and improve print quality

Jlm

What Do I Need to Know?

Safety Considerations

• **Ventilation** - Ensure adequate airflow, especially with ABS and other materials

• **Fire Safety** - Never leave printer unattended for long periods, install smoke detectors nearby

• **Hot Surfaces** - Be cautious around heated bed and nozzle (can reach 250°C+)

Jim

Popular CAD Programs for 3D Printing Design

Beginner-Friendly Options

• **Tinkercad** - Browser-based, completely free, drag-and-drop interface perfect for learning basic 3D modeling concepts

• **Fusion 360** - Professional-grade software with free personal license, excellent tutorials, and parametric modeling capabilities

• **SketchUp Free** - Intuitive push-pull modeling system, web-based version available, great for architectural and simple mechanical designs

Kyle and Jim

Tinkercad- Who's familiar with the term "WYSIWYG" (spoken as "wizzy-wig")? That's Tinkercad. Dead-simple, basic modeling tool. I'll demo it in just a second. You can pick this up in seconds and make just about any simple design.

Design Demonstration of TinkerCAD

Kyle Bandy demonstrates simple design concepts using TinkerCAD.

Use “3D design Coax Cable Clamp” as a starter

Describe the parts

Demonstrate resizing the coax

Show-off calipers

Popular CAD Programs for 3D Printing Design

Intermediate to Advanced

• **Blender** - Completely free, powerful for organic shapes and artistic designs, steep learning curve but extremely capable

• **Onshape** - Cloud-based professional CAD, free for public projects, collaborative features and version control

Popular CAD Programs for 3D Printing Design

Specialized Options

• **OpenSCAD** - Code-based modeling perfect for programmers, parametric designs, excellent for repetitive or mathematical objects

• **FreeCAD** - Open-source parametric modeler, completely free, good for mechanical parts but steeper learning curve

• **Meshmixer** - Free Autodesk tool specifically for preparing and repairing 3D models for printing

Popular CAD Programs for 3D Printing Design

Choosing the Right Software

• **Start with Tinkercad** - Learn basic 3D concepts before moving to more complex software

• **Fusion 360 for Mechanical** - Best balance of power and accessibility for functional parts and assemblies

• **Blender for Artistic** - Choose for miniatures, sculptures, and organic shapes

• **Consider Your Goals** - Simple prototypes vs. professional parts vs. artistic creations require different tool approaches

Popular 3D Slicers and Configuration

Most Popular Slicers

• **Cura** - Free, open-source, supports most printers, beginner-friendly with extensive plugin ecosystem

• **Prusa Slicer** - Free, excellent default settings, works with all printers (not just Prusa), advanced features like paint-on supports

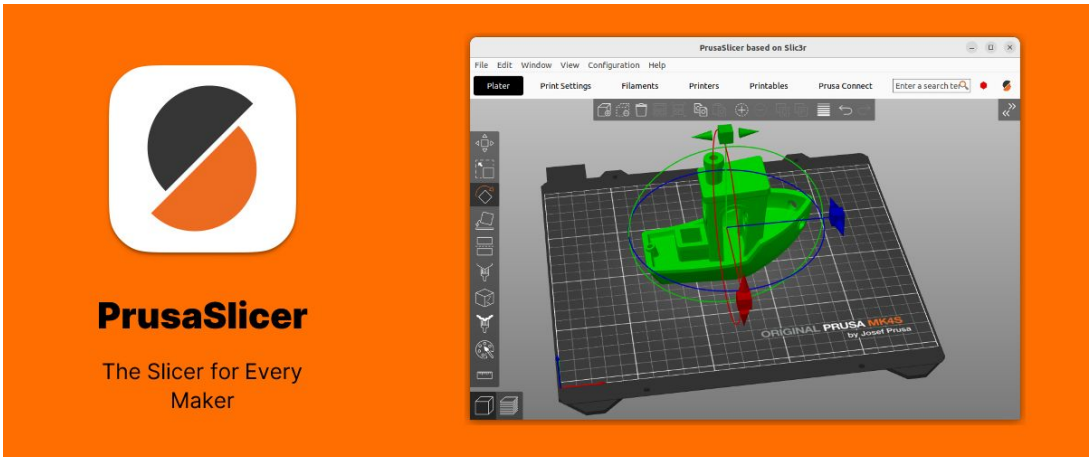
• **Bambu Studio** - Based on PrusaSlicer, optimized for Bambu printers but works with others, sleek interface

• **Orca Slicer** - Fork of Bambu Studio, community-driven, frequent updates, excellent calibration tools

Kyle and Jim

Demonstration of PrusaSlicer

Kyle shows how to move a .stl file to Cura slicer.



Take the Coax-Stay Model and slice it in PrusaSlicer

Demonstrate:
Quality selection
Material selection
Scaling
Rotation
Filament usage, time, and cost

Popular 3D Slicers and Configuration

Advanced Options

• **SuperSlicer** - Fork of PrusaSlicer with additional features, more granular control over settings

• **IdeaMaker** - Professional slicer by Raise3D, powerful but steeper learning curve

• **Simplify3D** - Paid software with advanced support generation, excellent troubleshooting tools

Popular 3D Slicers and Configuration

Initial Printer Configuration

• **Select Your Printer** - Choose from built-in profiles or create custom profile with your printer's specifications

• **Set Build Volume** - Enter your printer's maximum X, Y, Z dimensions and bed shape (rectangular/circular)

• **Configure Extruder** - Set nozzle diameter (typically 0.4mm), filament diameter (usually 1.75mm), and extruder count

• **Bed Settings** - Input heated bed capability, bed leveling type (manual/auto), and first layer calibration

Popular 3D Slicers and Configuration

Essential Settings to Configure

• **Layer Height** - Start with 0.2mm for good balance of speed and quality

• **Print Speed** - Begin with conservative speeds (50mm/s) and increase as you gain experience

• **Temperature Settings** - Use manufacturer's recommended temperatures for your filament type

• **Retraction Settings** - Adjust distance and speed to minimize stringing between parts

Popular 3D Slicers and Configuration

Follow Slicer Instructions

• **Built-in Wizards** - Most slicers offer setup wizards that guide you through initial configuration step-by-step

• **Calibration Tests** - Use slicer's built-in calibration prints (temperature towers, retraction tests) to fine-tune settings

• **Profile Management** - Save working configurations as custom profiles for different materials and quality levels

Popular 3D Filaments and Their Uses

Beginner-Friendly Materials

• **PLA (polylactic acid)** - Easy to print, biodegradable, minimal warping, ideal for prototypes, decorative items, and learning

• **PETG (polyethylene terephthalate glycol)** - Chemical resistant, food-safe options available, good clarity, perfect for containers, mechanical parts, and protective equipment

Kyle

Both are easy to print and don't require that the printer be placed in a temperature-controlled enclosure. Neither produces pungent odors during the printing process… but probably still a good idea to let your printer print in it's own, isolated room.

PLA- inexpensive, ideal for prototyping your designs to make sure measurements are correct, will sag in heat, very brittle in cold temps

PETG- durable, strong, weather-resistant

There are many, many more options out there. These are one newbie friendly ones.

Popular 3D Filaments and Their Uses

Engineering Materials

• **ABS (Acrylonitrile Butadiene Styrene)** - Strong, heat resistant, requires heated bed, excellent for automotive parts, electronics housings, and durable tools

• **ASA** - UV-resistant version of ABS, weatherproof, ideal for outdoor applications, car parts, and garden tools

• **Nylon** - Extremely strong and flexible, requires high temperatures, perfect for gears, bearings, and mechanical components

Popular 3D Filaments and Their Uses

Specialized Materials

• **TPU (Thermoplastic Polyurethane)** - Flexible rubber-like material, excellent for phone cases, gaskets, and wearable items. Polyurethane is excellent for designing capacitors for mag loops as it does not heat and melt from RF.

• **WOOD-filled PLA** - Contains real wood fibers, can be sanded and stained, great for decorative items and artistic projects

• **CARBON FIBER** - Lightweight and extremely strong, expensive, ideal for drone parts, automotive components, and high-performance applications

Popular 3D Filaments and Their Uses

Support Materials

• **PVA (Polyvinyl Alcohol)** - Water-soluble support material, dissolves completely, perfect for complex overhangs and internal geometries

• **HIPS (High Impact Polystyrene)** - Dissolvable in limonene, good support material for ABS prints, also suitable for lightweight parts

Popular 3D Filaments and Their Uses

Choosing the Right Filament

• **Start with PLA** - Most forgiving material while learning printer operation and basic techniques

• **Consider End Use** - Outdoor exposure requires ASA/ABS, flexible parts need TPU, mechanical stress needs Nylon

• **Temperature Limitations** - PLA softens at 60°C, ABS handles 80°C+, consider application environment

• **Post-Processing** - Some materials can be sanded, painted, or chemically smoothed for better finish

Jim

Good 3D Printer Brands with Active Support Groups

Budget-Friendly with Strong Communities

• **Creality (Ender 3, CR-10)** - Massive global community, extensive modifications available, active Reddit forums and YouTube channels

• **Prusa Research** - Outstanding community support, comprehensive knowledge base, active forums with developer participation

• **Bambu Lab** - Rapidly growing community, excellent official support, active Discord and Reddit communities

Jim and Kyle

Kyle on Prusa: The Prusa i3 MK3S was released in February 2019. That's over 6.5 years ago. Prusa still regularly updates the PrusaSlicer software as well as the firmware for the printer. And with an add-on devices, you can fully control the printer remotely.

Active Support Groups

Community Support Characteristics

• **Reddit Communities** - Most brands have dedicated subreddits with daily troubleshooting help

• **Discord Servers** - Real-time chat support, screen sharing for troubleshooting, regional channels

• **YouTube Channels** - Brand-specific content creators, modification guides, and troubleshooting videos •

Official Forums - Direct access to manufacturers, firmware updates, and technical documentation

Kyle

Beginner 3D Printer Costs and Where to Buy Them

Budget Entry Level ($100-200)

- **Creality Ender 3 V2** - $150-180, requires assembly, excellent modification potential
- **Anycubic Kobra 2** - $160-190, auto-leveling, good build quality for price point
- **Elegoo Neptune 3** - $170-200, silent drivers, decent build volume
- **Artillery Sidewinder X2** - $180-220, large build volume, direct drive extruder

Jim

Beginner 3D Printer Costs and Where to Buy Them

Mid-Range Beginner ($200-400)

• **Prusa MINI+** - $350-400, excellent reliability, outstanding support, smaller build volume

• **Bambu A1 Mini** - $300-350, automated features, beginner-friendly, compact size

• **Creality K1C** - $280-320, enclosed design, faster printing speeds

• **Anycubic Kobra 2 Pro** - $250-300, auto-leveling, larger build volume

Jim

Beginner 3D Printer Costs and Where to Buy Them

Premium Beginner ($400-800)

• **Prusa MK4** - $750-800, industry gold standard, exceptional reliability and support

• **Bambu X1 Carbon** - $1200-1300, fully automated, professional features, enclosed chamber

• **Qidi Tech X-Max 3** - $600-700, enclosed, handles advanced materials

• **Ultimaker 2+ Connect** - $2000+, professional grade, excellent for education/business

Jim

Kyle:

The HeathKit 3D Printer… if only

Beginner 3D Printer Costs and Where to Buy Them

Where to Buy - Direct from Manufacturers

- **Prusa3D.com** - Official Prusa store, best warranty support, genuine parts guaranteed
- **Bambulab.com** - Direct sales, full warranty, latest firmware updates
- **Creality3D.com** - Official store, worldwide shipping, authentic products

Beginner 3D Printer Costs and Where to Buy Them

Where to Buy - Major Retailers

• **Amazon** - Fast shipping, easy returns, but verify seller authenticity and warranty coverage

• **Micro Center** - Physical stores, in-person support, price matching, good for immediate pickup

• **Newegg** - Competitive pricing, frequent sales, good for bulk orders or bundles

• **3D-Fuel-** American-made filament at good prices with free shipping on orders over $75

Kyle

Amazon offers very inexpensive filament, but could be low quality.

Micro Center is a local source of decent quality filament with an enormous selection (photo on next slide).

NewEgg also offers decent pricing.

Beginner 3D Printer Costs and Where to Buy Them

Specialty 3D Printing Retailers

• **Microcenter** - Support our local vendor with a selection of popular printers

• **MatterHackers** - Excellent customer service, curated selection, educational resources

• **Printed Solid** - Specialized knowledge, pre-assembled options, good technical support

Filament.ca - Canadian retailer, good selection, local support for North American customers

Beginner 3D Printer Costs and Where to Buy Them

Cost-Saving Tips

• **Sales Timing** - Black Friday, back-to-school, and end-of-year sales offer 20-30% discounts

• **Refurbished Options** - Many manufacturers offer refurbished units at 15-25% savings

• **Kit vs. Assembled** - Kit versions typically cost $50-100 less but require 2-6 hours assembly time

• **Bundle Deals** - Starter packages with filament and tools often provide better value than individual purchases

Kyle

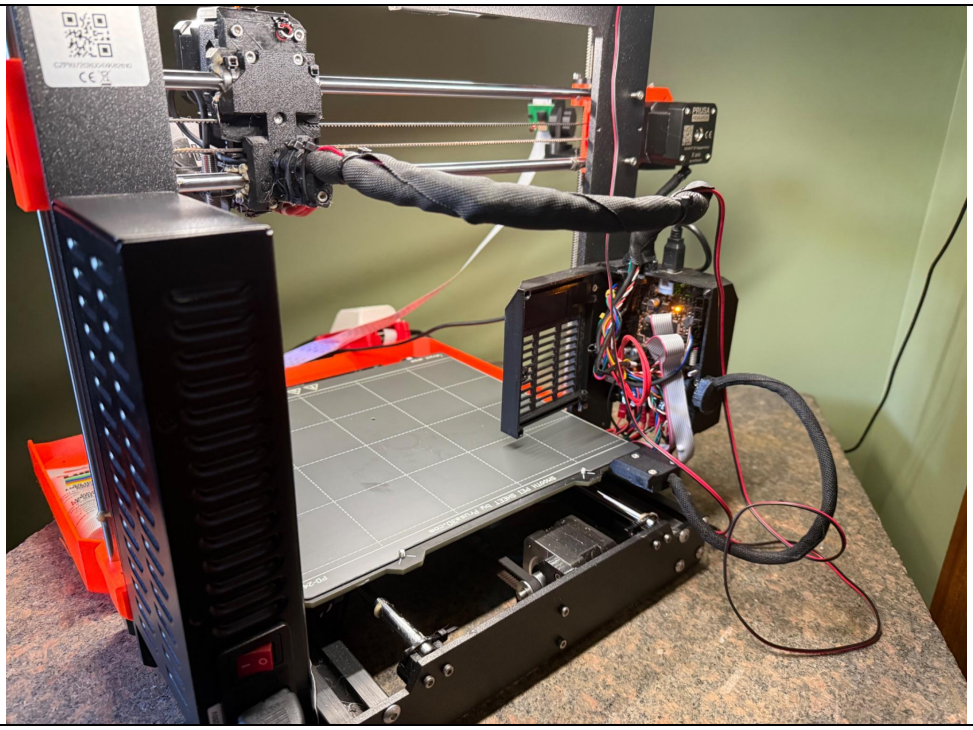
Cost-saving tips

Look for sales

Consider purchasing a refurbished printer. As you can tell from this presentation, 3D printers aren't nearly as "Plug-'n-Play" as 2D printers. There are likely a ton of printers out there that people have purchased, couldn't figure out, and they either returned or they'll sell at your local garage sale.

Consider buying your printer in kit-form. Hams love kits! Prusa i3 MK4S (currently version of their mid-size printer) is $669 for the kit, versus $929 assembled. If you buy the kit, you won't be daunted by repair tasks. (Show the installation guide for Prusa.) (Show photo on next slide of repair I did last week.)

Bundle printer with filament for additional savings.



Websites to Download 3D Printable Objects

Most Popular Free Sites

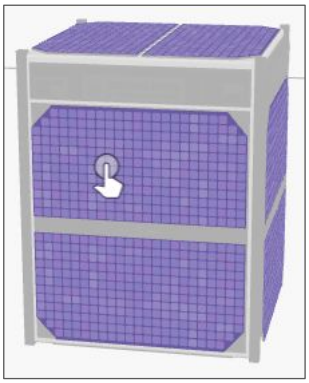
- **Thingiverse** - Largest collection, completely free, active community, wide variety from practical to artistic
- **Printables (Prusa)** - High-quality curated models, excellent search filters, growing rapidly, rewards system for designers
- **MyMiniFactory** - Quality-focused, tested models, strong miniature gaming community, mix of free and paid content
- **Cults3D** - Mix of free and premium models, unique designs, good for artistic and decorative items

Kyle

Websites to Download 3D Printable Objects

Specialized Communities

- **STLFinder** - Search engine that indexes multiple sites, finds models across platforms simultaneously
- **GrabCAD** - Engineering-focused, professional mechanical parts, CAD files available, requires free registration
- **NASA 3D Models** - Official NASA repository, spacecraft and astronomical objects, educational content
- **NIH 3D Print Exchange** - Medical and scientific models, educational anatomy, research-based designs



Kyle

Websites to Download 3D Printable Objects

Premium/Paid Platforms

• **CGTrader** - Professional quality models, mix of free and paid, detailed licensing information

• **TurboSquid** - High-end commercial models, expensive but professional quality, extensive licensing options

• **Gambody** - Premium gaming and pop culture models, subscription-based, highly detailed designs

• **MyMiniFactory Premium** - Curated premium content, supports independent designers, quality guarantee

Websites to Download 3D Printable Objects

Gaming and Miniatures

- **Heroforge** - Custom miniature creator, paid service, personalized RPG characters
- **Fat Dragon Games** - Tabletop terrain and accessories, subscription model, D&D focused
- **One Page Rules** - Free army miniatures, simple licensing, wargaming focused
- **Epic Miniatures** - Patreon-based, monthly releases, high-quality fantasy miniatures

Jim

Websites to Download 3D Printable Objects

Educational and Functional

• **Instructables** - DIY projects with 3D printed components, step-by-step guides, community-driven

• **YouMagine** - Ultimaker's platform, functional designs, open-source focus, good documentation

• **3DPrintr.com** - Open-source only, freedom-focused licensing, community-maintained

• **Appropedia** - Sustainability-focused, practical applications, developing world solutions

Websites to Download 3D Printable Objects

Tips for Finding Quality Models

• **Check Reviews** - Look for user comments, photos of printed results, and ratings before downloading

• **Read Print Settings** - Verify model includes recommended layer height, infill, and support requirements

• **License Awareness** - Understand Creative Commons licenses, especially for commercial use or modifications

• **File Formats** - Ensure STL files are included, check for multi-part assemblies and print orientation guides

Sources of 3D Printing Information

Comprehensive Online Resources

• **All3DP.com** - Extensive guides, reviews, and tutorials including their comprehensive 101 guide at https://all3dp.com/3d-printing-3d-printer-guide-101-questions/#google_vignette

• **3D Printing Industry** - Industry news, professional insights, market trends, and technical developments

• **MatterHackers** - Educational articles, material guides, troubleshooting resources, and how-to tutorials

• **Prusa Knowledge Base** - Detailed technical documentation, calibration guides, and problem-solving resources

Jim

Sources of 3D Printing Information

Video Learning Platforms

• **YouTube Channels** - Teaching Tech, CHEP, CNC Kitchen, and Makers Muse offer excellent tutorials and reviews

• **Udemy/Coursera** - Structured courses on 3D printing fundamentals, CAD design, and advanced techniques

• **LinkedIn Learning** - Professional development courses focused on industrial applications and business use cases

• **Skillshare** - Creative-focused tutorials for artistic and design applications

Sources of 3D Printing Information

Community Forums and Discussion

• **Reddit Communities** - r/3Dprinting, r/FixMyPrint, r/functionalprint for real-time help and community support

• **Discord Servers** - Brand-specific servers (Prusa, Bambu, Voron) for immediate troubleshooting assistance

• **Facebook Groups** - Local 3D printing groups, brand-specific communities, and specialized interest groups

• **Official Forums** - Manufacturer forums for technical support and firmware updates

Sources of 3D Printing Information

Technical Documentation

• **Reprap.org** - Open-source hardware documentation, firmware guides, and modification instructions

• **Marlin Firmware Documentation** - Comprehensive guide for firmware configuration and advanced settings

• **Klipper Documentation** - Advanced firmware information for high-performance printing setups

• **OctoPrint Documentation** - Remote monitoring and control system guides

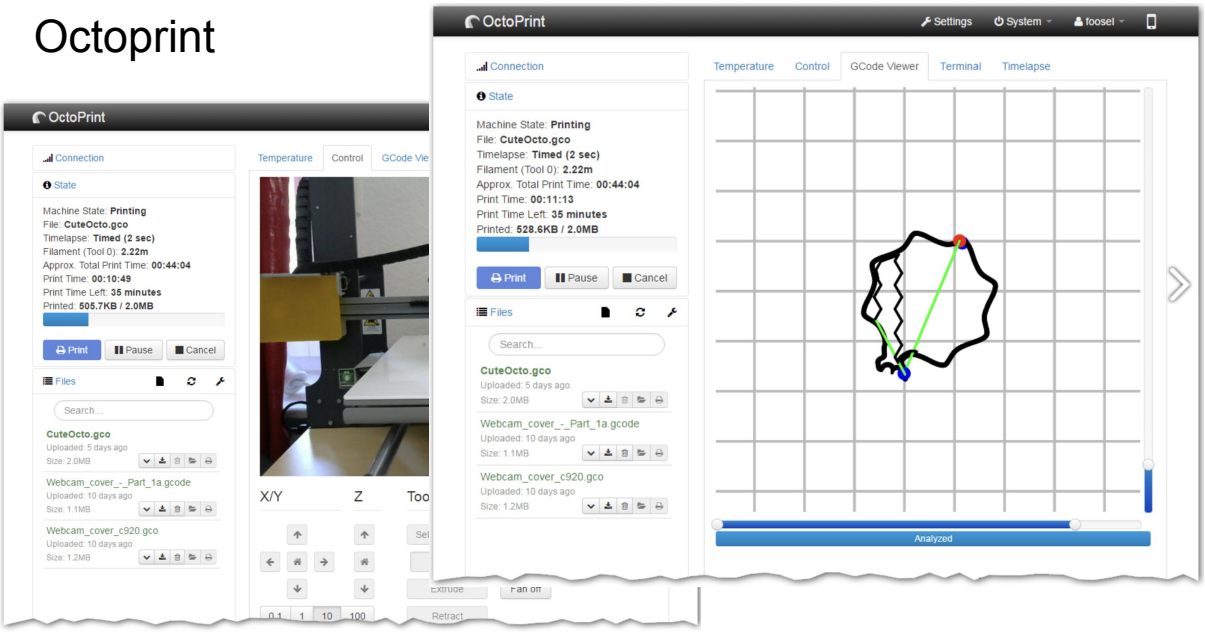
Remote Printing

- Octoprint
- Klipper

Jim and Kyle

Octoprint Screenshots on next slides

Octoprint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Size: 2.0MB
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Uploaded: 10 days ago
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Terminal
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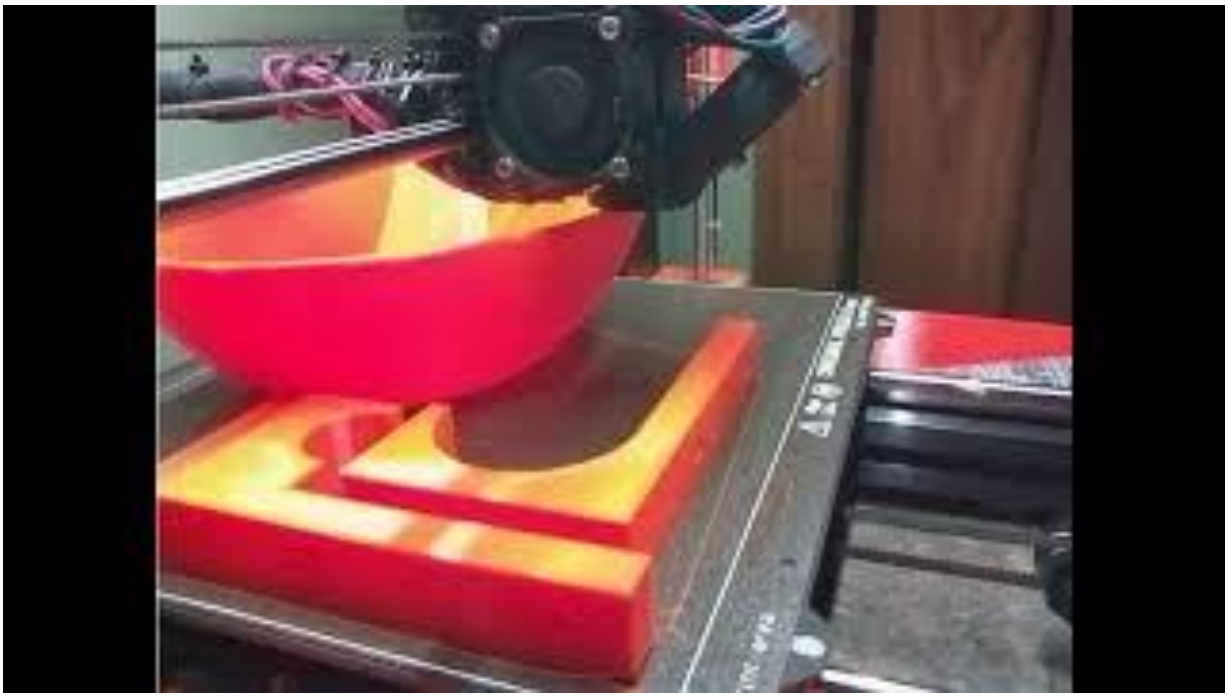

Sources of 3D Printing Information

News and Industry Updates

• **3DPrint.com** - Daily news, industry analysis, product launches, and market insights

• **3D Printing Media Network** - Professional industry coverage, trade show reports, and business applications

• **Additive Manufacturing Magazine** - Industrial focus, advanced materials, and commercial applications

• **TCT Magazine** - Trade publication covering manufacturing technologies and industry trends

Sources of 3D Printing Information

Local Resources

• **Maker Spaces** - Hands-on learning, equipment access, and local community support

• **Public Libraries** - Many offer 3D printing services, classes, and equipment access

• **Community Colleges** - Courses on additive manufacturing, CAD design, and technical skills

• **Local 3D Printing Groups** - Meetups, workshops, and peer-to-peer learning opportunities

Sources of 3D Printing Information

Manufacturer Resources

• **Official Websites** - Prusa, Bambu, Ultimaker, and others provide extensive documentation and support

• **User Manuals** - Comprehensive setup guides, maintenance schedules, and troubleshooting steps

• **Firmware Updates** - Latest features, bug fixes, and performance improvements

• **Customer Support** - Direct technical assistance and warranty information

It’s A Hobby

- Four essential tools
- You will have to invest time to be successful
- You don’t have to be perfect. If a hole is slightly too small, don’t reprint: use a drill bit
- You can learn as you go

Both wrap up

Thank You!

Questions?

Scan QR code for link to slides