

*Learning The
Art of 3D CNC
Woodworking*



**Basic tips from a student
who has “been there, done that”.**

BY JOEL CASSOLA



DON'T LET ANYONE FOOL YOU. It takes many, many hours to learn the art of programming a CNC (Computer Numerical Control) router. However, once you do, you can quickly produce and replicate truly amazing sculptured wood product designs. Just ask Kenny Ham, a recent graduate of Monterey High School in Lubbock, Texas.

Kenny was introduced to the CNC router (a Techno LC Series 4896 with a 4' by 8' table) in a sophomore woodworking class by technology education teacher Frank Anderson. It was Anderson's unique approach to teaching that enabled Kenny to assimilate a large amount of information and operating skill with this system in a very short amount of time.

Anderson said, "I don't have time to learn everything about everything. And I can't answer every question. What works best for me is to get them started with some basic instruction. Then, I find a real life project that I think they might be interested in doing. No real time limit on it. Not some big money thing. Just a very interesting situation. It can even be something you could do in a conventional way. But we throw the computerized part in there, and most kids seem to like that.

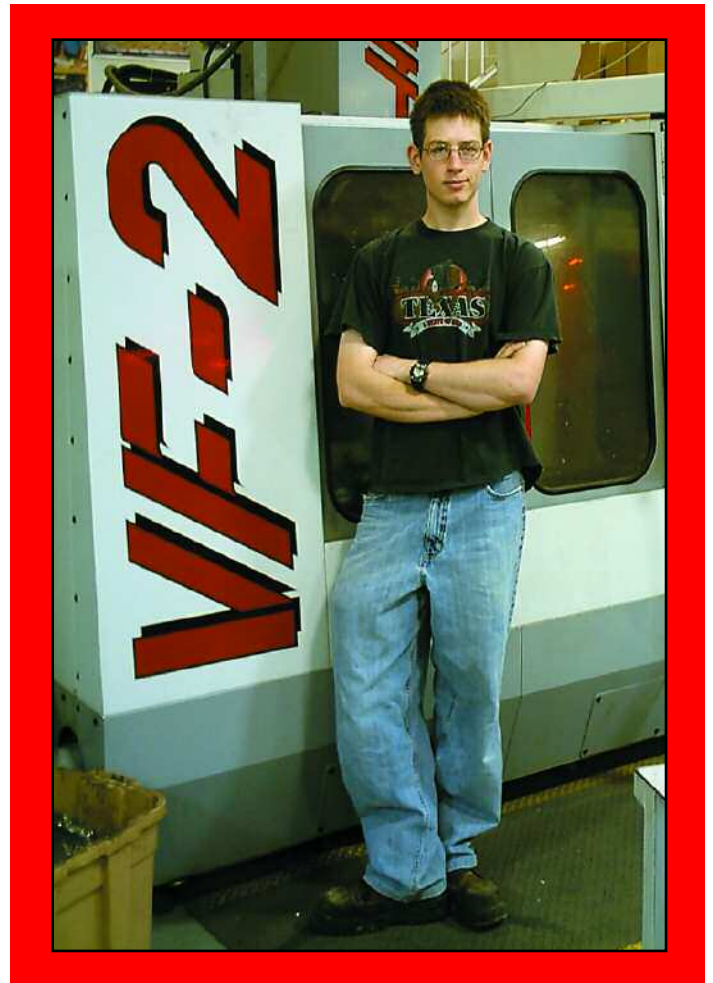
"I say, 'why don't you work on this a bit, but when you get to a place where you are stuck, come and get me'. (Of course, I don't do this with every student, just the self motivated ones.) And we will solve the problem together-- either during class or a break or after school.

If we both get stuck, I know people around town who work in those areas. I also have contacts with the manufacturers of the machinery and software. I will call them and say, "This is the problem I am having, what might be a solution?"

Taking It In Stages

Anderson has been perfecting his method over a 29-year teaching career. He uses it to draw students into their areas of interest and keep them so engaged they continue, like Kenny, to re-enroll in his classes for all three years of high school.

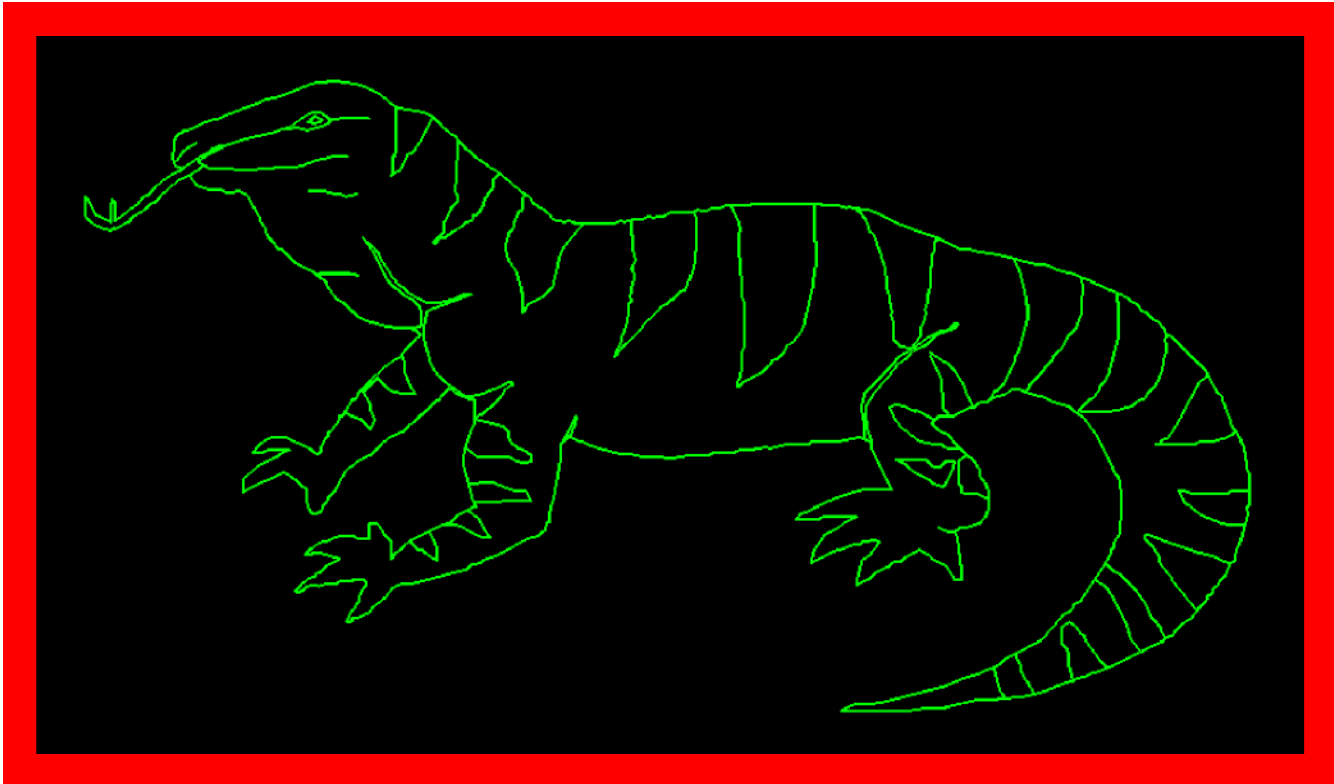
His approach involves taking the students through a series of progressive assignments that are not so difficult



Kenny Ham. Student, Monterey H.S. Lubbock TX.

as to be discouraging, but difficult enough to draw students out of their comfort zones. Then they have no choice but to learn something if they are to succeed. Here are some of the lessons Kenny learned on his route to becoming a proficient CNC Router Programmer (using Mastercam CAD/CAM Software, CNC Software, Tolland, CT) abstracted from papers he wrote himself. They serve as a model for self directed study for anybody who wants to learn how to use a CNC router for a lot more than cutting simple shapes and grooves.

CNC Graphics Processing. The first thing you need to know is how CNC equipment like the router uses geometric features (e.g. lines, circles, arcs, etc) to create sophisticated physical representations of images created in the CAD (computer aided design) program. To get started Anderson had Kenny Ham ground himself in



Basic 2D Training: First Kenny learned to create simple drawings in AutoCad, flow them into Mastercam software and create simple 2D tool paths for engraving the design.

knowledge on how to create the illusion of 3D images using 2D graphics.

From there he experimented with creating simple 3D objects using CAD (computer automated design) and CAM (computer aided manufacturing) software. Where 2D drawings give the appearance of depth by using different colors and shading, wooden objects manufactured on the router create actual depths, up to two inches, on the equipment Kenny was using.

Simple Objects - Learning to walk before he ran, Kenny practiced bringing simple CAD drawings into his Mastercam software and creating tool paths that would instruct the router on how to cut out these shapes. This basic work included engraving 2D images on blocks of wood and cutting the wood according to specific patterns.

2.5D Objects - Beyond creating 2D engravings and profiles, CNC Routers can actually produce artifacts with multiple layers of depth. The simplest of these are 2.5D

designs, which consist of multiple 2D cutting paths created at various depths to provide a 3D look and feel. Once Kenny mastered cutting 2D pieces on a single plane, it was relatively easy for him to program 2.5D designs that the router cuts on multiple planes.

Adding another layer of sophistication, Kenny learned how to use Mastercam's unique raster-to-vector function to convert imported photographs and line art into line designs that can be readily segmented into multiple layers creating lifelike 2.5D plaques like the Rolex™ watch shown in the photo.

Full 3D - CNC routers can also create continuous smooth contoured surfaces in 3 dimensions. This capability is far more sophisticated than 2.5D programming but the CAD software has many built-in routines that help Kenny translate 3D designs created in CAD into cutting paths that are executed on the CNC router.



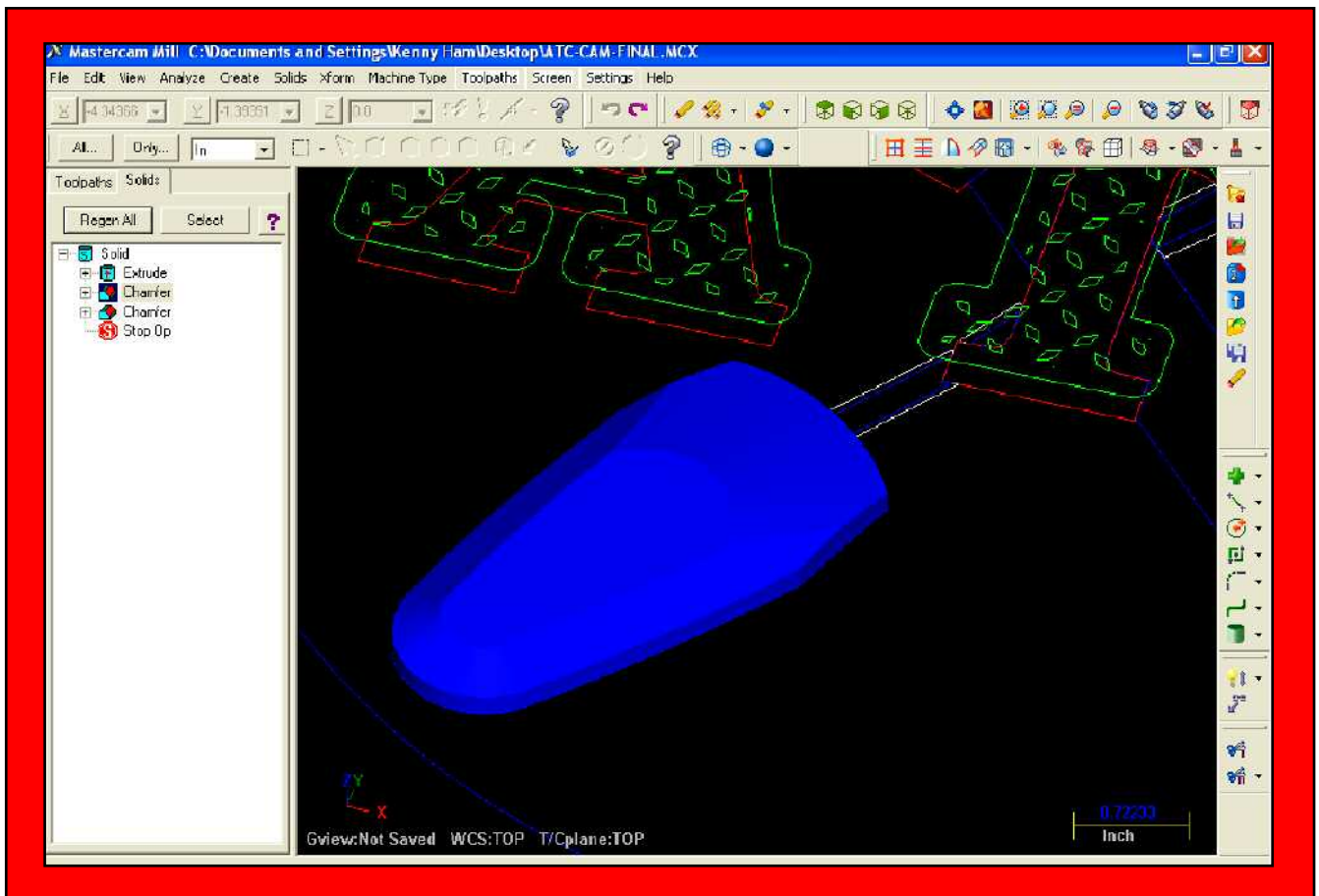
Putting It All Together

Looking for a project to test all of his CNC woodworking skills, Kenny chose to create a plaque that would graphically depict all of the programs taught at the ATC (Advanced Technology Center) where he took most of his courses. These included woodworking, metalworking, computer science, automotive and electrical programs. The goal was to represent all of the programs while maintaining a simplicity that would keep the plaque from appearing cluttered.

In his own words, “The first idea I had was to use a saw blade for the outline of the plaque, which would represent the carpentry program. I would have the ATC letters raised on the top of this saw blade with the letters having a metal-looking, diamond-plate effect to them to represent the metal trades program. Kenny showed his original design, created in AutoCAD to a number of teachers and fellow students.

“After analyzing the feedback I received, I was able to come up with a few good ways to add to the plaque without cluttering it up, while still representing every course category offered at the ATC. The improvements were to include a mechanic's wrench for the auto program and computer mouse (obviously for the computer courses) in a “coat-of-arms” fashion with the mouse having an electrical plug for a tail (the electrical programs) instead of a regular computer plug. These additions would represent the three course areas (auto, computer, and electrical) that I had not covered with my first design.”

Kenny machined a prototype of his 2.5D plaque from a board he made by gluing together two pieces of 3/4 brown oak. These additions would also not be too hard to machine, or so I thought at the time. However, when I machined my first prototype, the top of the mouse was flat, and people kept commenting on how it should be rounded.



Sculptured 3D. To make the mouse in his plaque look more realistic, Kenny used the Mastercam solids feature to create paths that would allow the router to continuously sculpture this part of the design.



Mastercam X got me my dream job!

“Learning Mastercam in school got me into OCC. This is my dream job and I love it here, even though it gets pretty stressful with those big guys pushing to hit deadlines. Mastercam sure helps make my job easier.”

– Ty Kropp, Machinist, Orange County Choppers



The Easy part, watching the CNC lathe carve his design out of solid oak.

“Not knowing what I was getting myself into, I proceeded to try and draw the whole plaque as a solid which is the method used to machine rounded surfaces. After more trial and error than I care to admit to, I finally figured out that all I had to do was make the rounded mouse a solid, and machine the rest of the plaque in normal 2.5D fashion.”

The solids tool path feature of Mastercam X made it easy for Kenny to embed a realistic sculptured mouse into his otherwise 2.5D plaque design which he ultimately cut from a piece of oak using a 1/8-inch ball end mill and a 1/4-inch flat end mill for the finish work. Kenny sanded and polished his plaque and it was ready for display.

Kenny Moving On

During his first couple years at Monterey High Kenny completed many CNC projects for faculty friends and family, using every experience to expand his knowledge of CAD/CAM software and CNC operation. One of Kenny’s projects was to help with the Lubbock Legacy Play Village Project by volunteering to custom engrave fence pickets with the CNC router. This brought in many \$25 dollar donations for the project. Kenny also used his CNC skills to advantage in projects that led to his becoming an Eagle Scout.

Kenny plans to become a mechanical engineer, and comments, “learning CNC machining has been a great experience for helping me prepare for engineering college. I could start with small projects that did not



Completed Project. This design used 2D, 2.5D and 3D tool paths created in Mastercam CAD/CAM software and cut from oak on a CNC Lathe to simply depict all of the programs offered at the Advanced Technology Center.

require any sophisticated math, drafting skills, or much design effort on my part. From there, I gradually learned how to design bigger and better projects that made me learn the advanced math, and drafting skills needed to complete them.”

During his time at Monterey High School and the ATC, Kenny used his CNC skills to compete in many regional and national design competitions. These ranged from entering his Rolex and ATC plaques in Tech-Ed competitions, to participating in unique robot build challenges as well as the Mastercam “Innovator of the Future”, “Wildest Part” competitions.

This fall Kenny entered the engineering program as a freshman at Oklahoma Christian University. He is planning to use his CNC skills to get a job at a local woodworking or machine shop to pay college expenses. His innate curiosity about CNC woodworking continues to work very well for him



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