Woodcraft CNC Basics Class

Bill Caldwell

SCOPE OF THIS CLASS

- Examples
- CNC Background/ Control systems
- Process flow (CAD-CAM-Machining)
- Basic VCarve operations for Creating Projects
- Create a design for a plaque-Walk through the steps
- Design your own plaque
- Run Mach 3 and machine a plaque

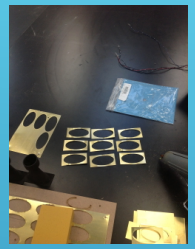
PROJECT IDEAS

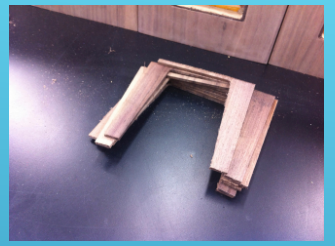
- Sign Making
- Engraving
- Creating Unique Shapes and Objects
- Inlays

PROJECTS EXAMPLES

WHAT'S POSSIBLE WITH CNC







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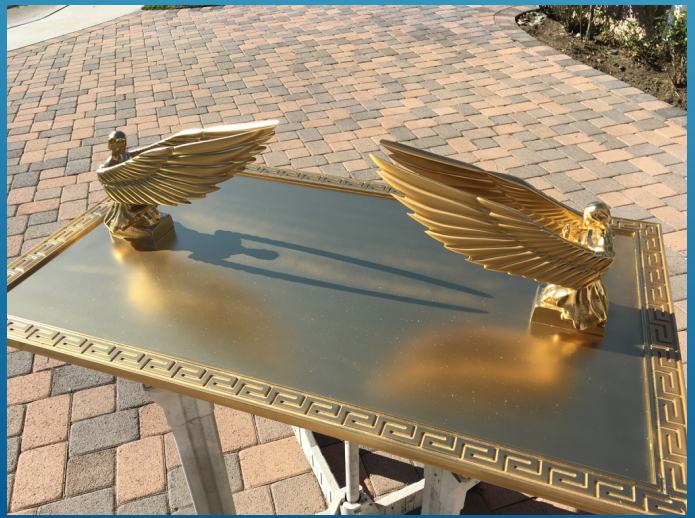

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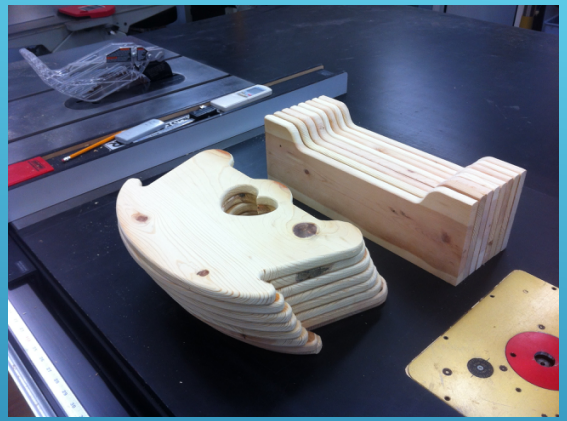

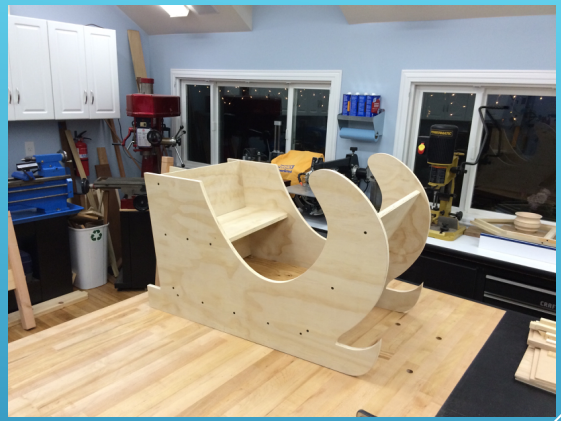

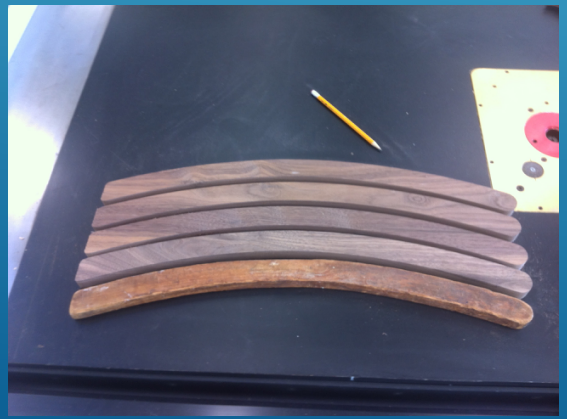

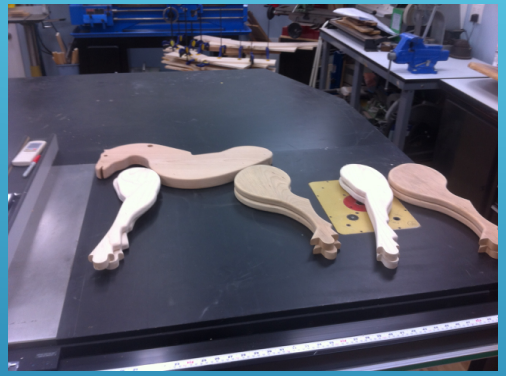

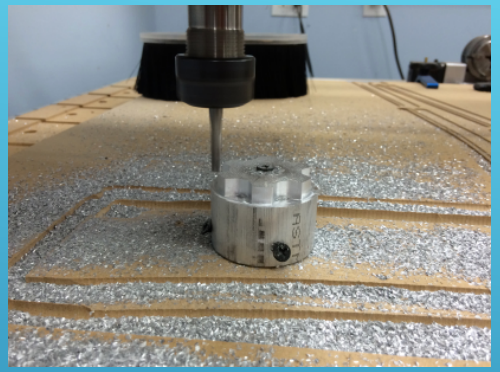

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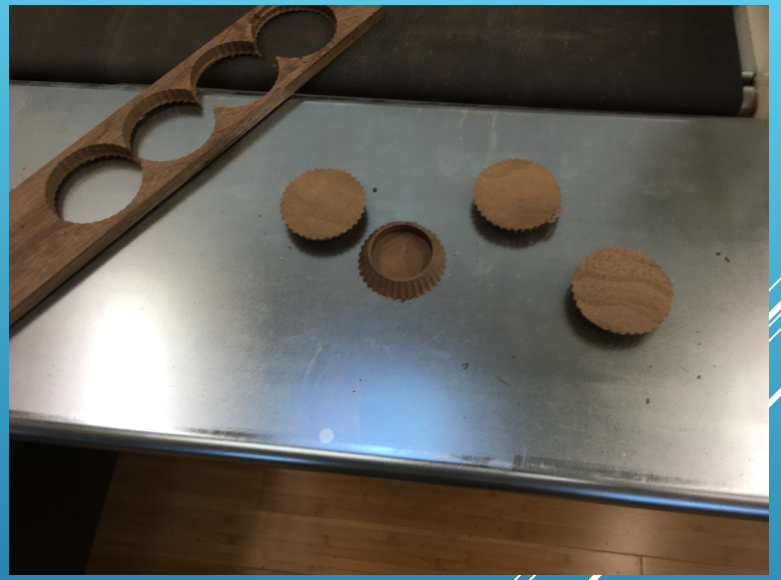

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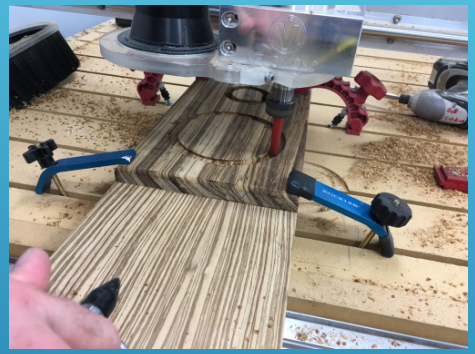

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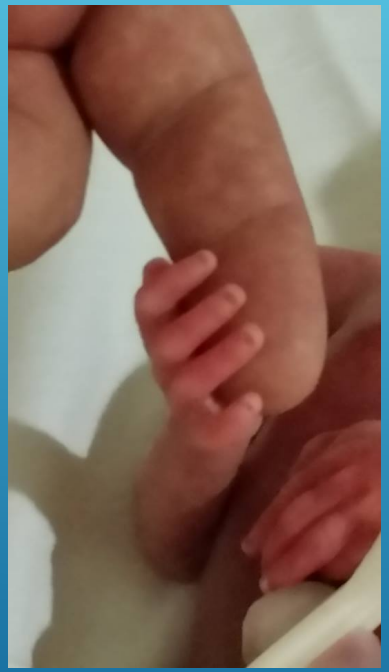

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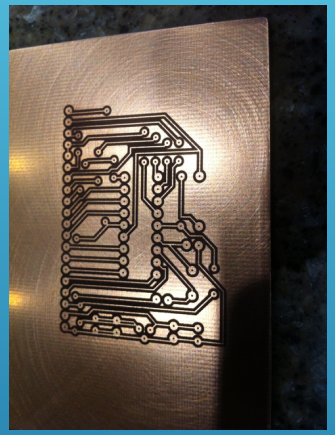
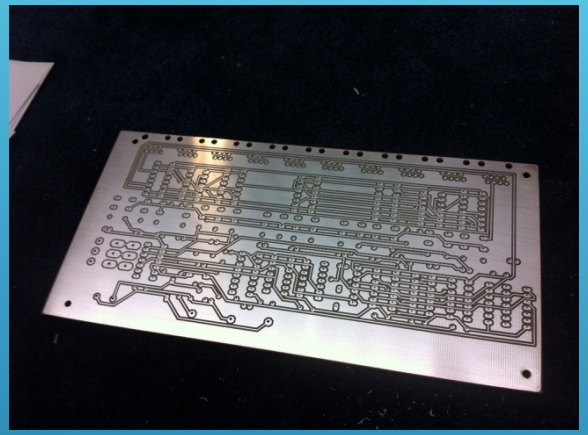
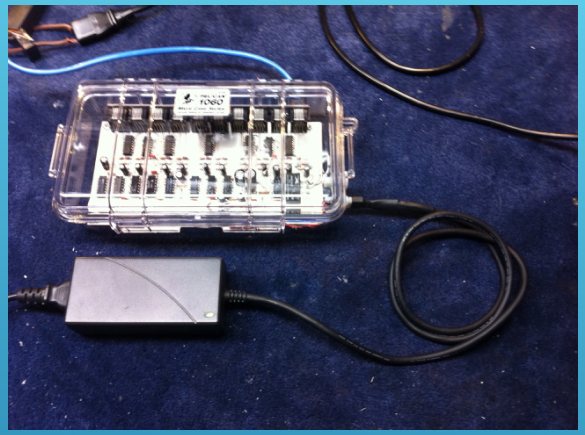
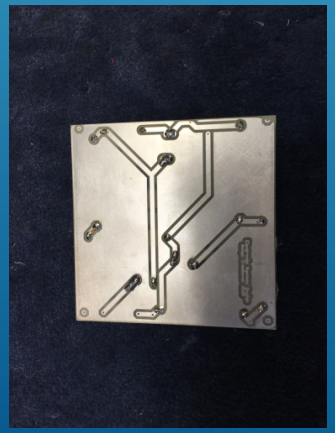
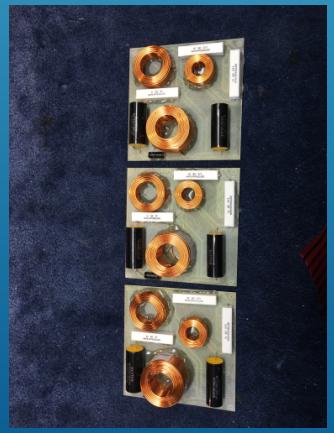






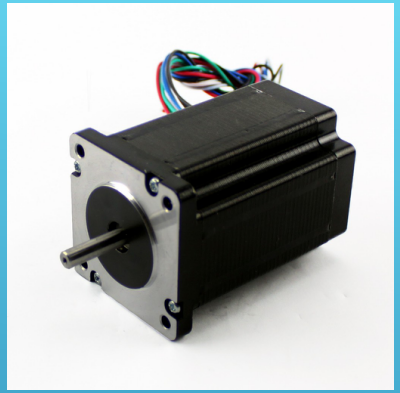




CNC-COMPUTER NUMERICAL CONTROL

- ROUTERS AND MILLING MOTORS DRIVEN BY A CONTROLLER TO MOVE IN THE X, Y, AND Z AXIS VERY ACCURATELY AND QUICKLY!
- MOST COMMON CNC MACHINES OPERATE WITH STEPS (INCREMENTAL MOVES) OF .001 INCHES.
- INDUSTRIAL CNC MACHINES CAN ADD MORE AXIS' WITH TABLE MOUNTED MOTIONS TO CREATE COMPLEX SHAPES.

Control Systems



- Open-Loop Control
  - Stepper motor system
  - Current pulses sent from control unit to motor
  - Each pulse results in a finite amount of revolution of the motor
  - Resolutions of .001 are possible

CONTROL SYSTEMS

- OPEN-LOOP ADVANTAGES
  - SIMPLE, INEXPENSIVE, LOWER MAINTENANCE COSTS
  -
- OPEN-LOOP LIMITATIONS
  - CONTROL UNIT “ASSUMES” DESIRED POSITION IS ACHIEVED
  - NO POSITIONING COMPENSATION
  - TYPICALLY, A LOWER TORQUE MOTOR

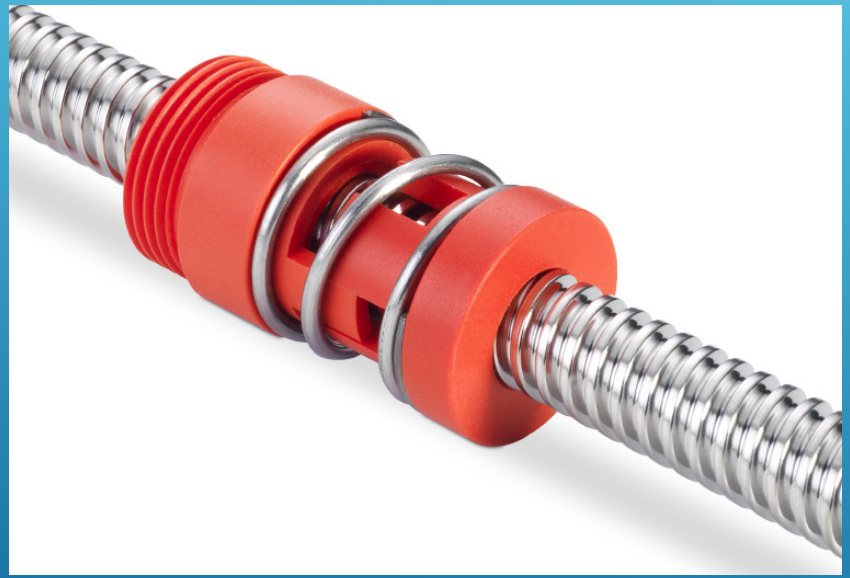
CONTROL SYSTEMS

- CLOSED-LOOP CONTROL
  - VARIABLE DC MOTORS - SERVOS
  - POSITIONING SENSOR -RESOLVER / ENCODER
    - FEEDBACK TO CONTROL UNIT
    - POSITION INFORMATION COMPARED TO TARGET LOCATION
    - LOCATION ERRORS CORRECTED

CONTROL SYSTEMS

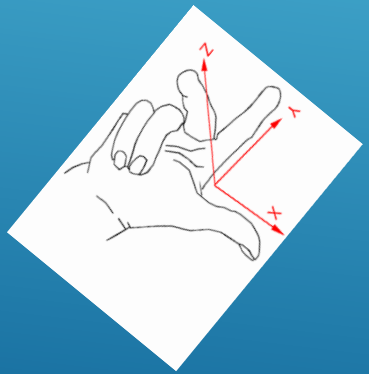
- Closed-Loop Advantages
  - DC motors have the ability to reverse quickly to adjust for position error
  - Error compensation allows for greater positional accuracy (.0001")
  - DC motors have higher torque ranges vs stepper motors
- Closed-loop limitations
  - Cost
  - Control System Complexity

ZERO BACKLASH LEAD SCREW

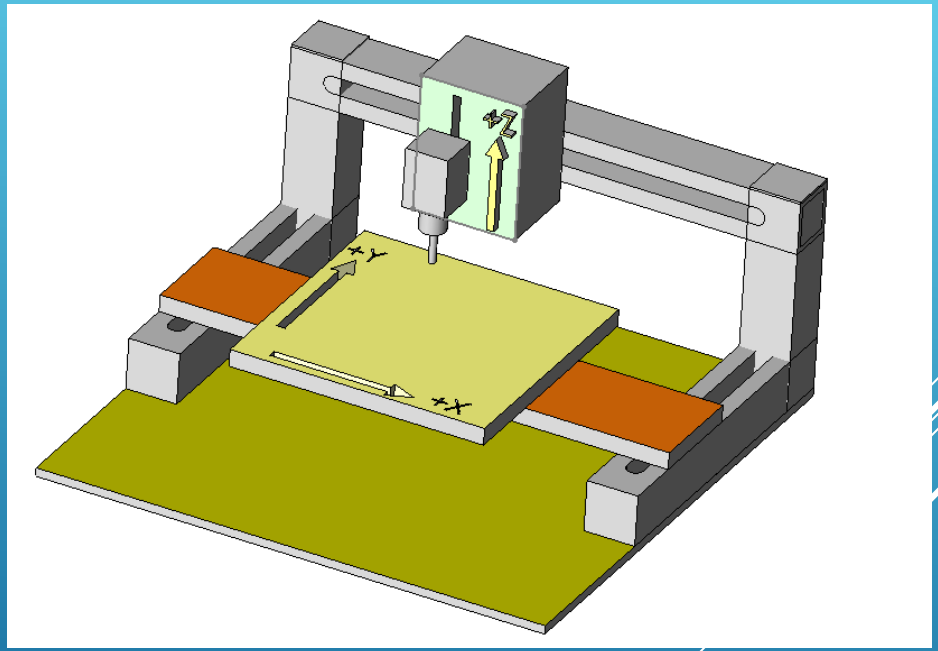


3 Axis Routing

- 3 Degrees of Freedom



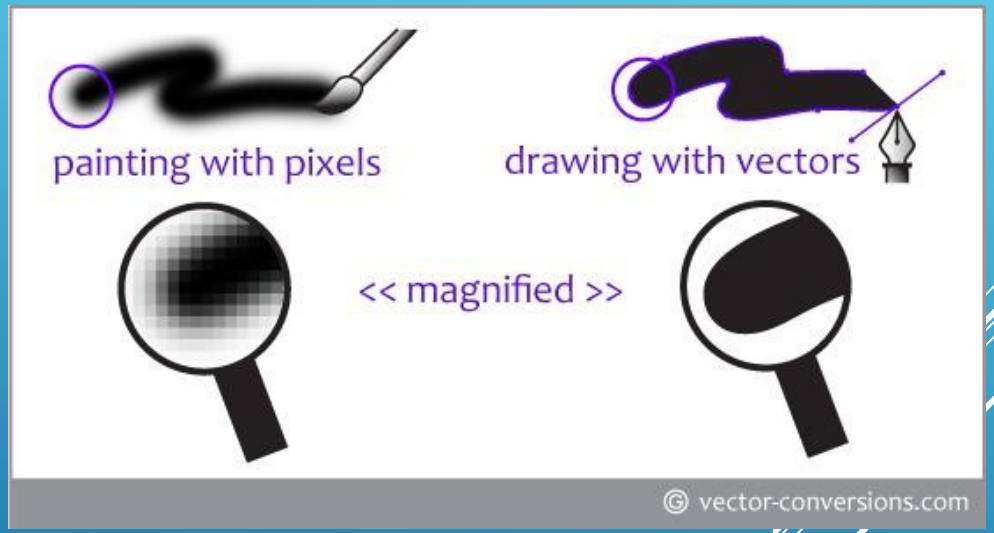
Axis orientation (Right Hand Rule)



RASTER VS VECTOR:

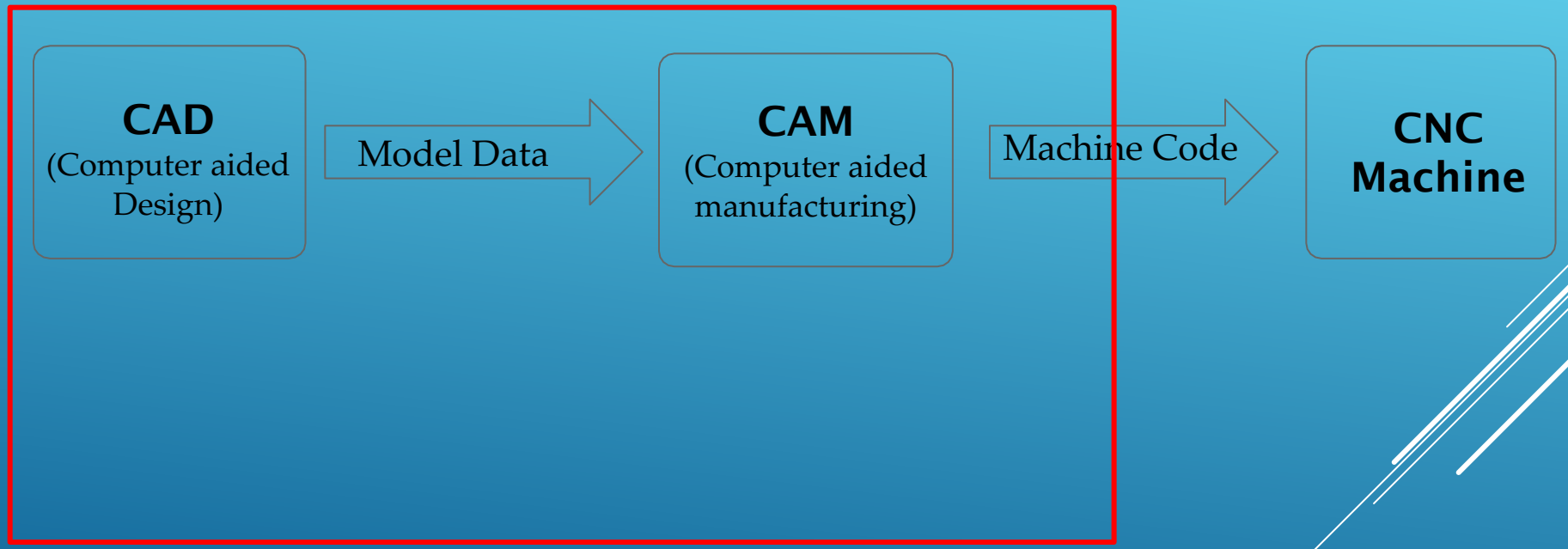
VECTOR DESIGNS

- Curved or straight lines instead of discrete pixels
- Lines have no width
- Can resize without degradation
- Common formats: SVG, AI, DXF



TYPICAL CNC WORKFLOW

VCARVE



V-Carve's Capabilities

CAD (DESIGN)

- GENERATE GRAPHIC REPRESENTATION OF PART
  - VECTORS USED TO REPRESENT PART
  - DIRECT INPUT
  - IMPORT FROM EXTERNAL SYSTEM
    - EXAMPLE DXF / IGES/ PDF
  - 2D OR 3D SCAN
    - MODEL OR BLUEPRINT
  - (AT THIS POINT YOU HAVE A GRAPHIC FILE OF YOUR GEOMETRY)

CAM (PATH)

- DEFINE CUTTER PATH BY SELECTING GEOMETRY
  - PROFILES
  - POCKETS
  - DRILL PATTERNS
  - FLUTING
  - TEXTURING
  - ENGRAVING
- (AT THIS POINT THE SYSTEM KNOWS WHAT YOU WANT TO CUT)

CAM (CUT PARAMETERS)

- DEFINE CUT PARAMETERS
  - TOOL INFORMATION
    - TYPE OF BIT, RPM, FEED SPEED
  - CUT METHOD
    - EXAMPLE: ZIG-ZAG, SPIRAL, INSIDE-OUT, CLIMB CUT, STANDARD CUT
    - ROUGH PASS AND FINISH PASS PARAMETERS
- (AT THIS POINT THE SYSTEM KNOWS HOW YOU WANT TO CUT THE PART)

CAM (SIMULATION)

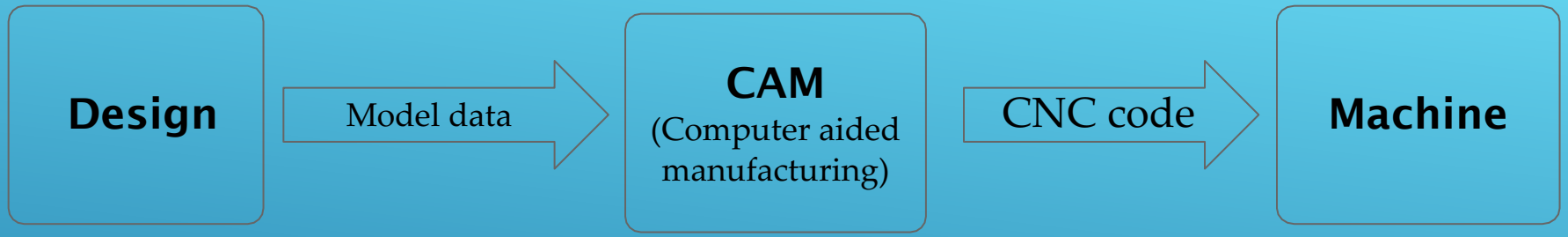
- EXECUTE CUTTER SIMULATION
  - VISUAL REPRESENTATION OF CUTTER MOTION
- MODIFY / DELETE CUTTER SEQUENCES AS NECESSARY

(AT THIS POINT THE SYSTEM HAS A “GENERIC” CUTTER LOCATION (CL) FILE OF THE CUT PATHS)

CAM (POST PROCESSING)

- POST PROCESSING
  - CL FILE TO MACHINE SPECIFIC NC CODE
- FILTERS CL INFORMATION AND FORMATS IT INTO NC CODE BASED ON MACHINE SPECIFIC PARAMETERS
  - WORK ENVELOPE
  - LIMITS - FEED RATES, TOOL CHANGER, RPM, ETC.
  - G & M CODE FUNCTION CAPABILITIES
- FINAL MACHINE OUTPUT COMMONLY CALLED G CODE

TYPICAL CNC WORKFLOW



CAD
Line Art
3D Model

Graphic File of your geometry
Examples:
DXF, PDF,IGES
Format

Layout
Profiles
Pockets
Hole Patterns
Engraving
Tool Selection
Feeds & Speeds
Types of cut:
Zig-Zag, Spiral, Inside Out
Standard Cut, Climb Cut
Roughing and Finishing Parameters
Simulation
Post Processing to Machine Code

Machine Code
(G-Code)

OTHER DESIGN SOFTWARE

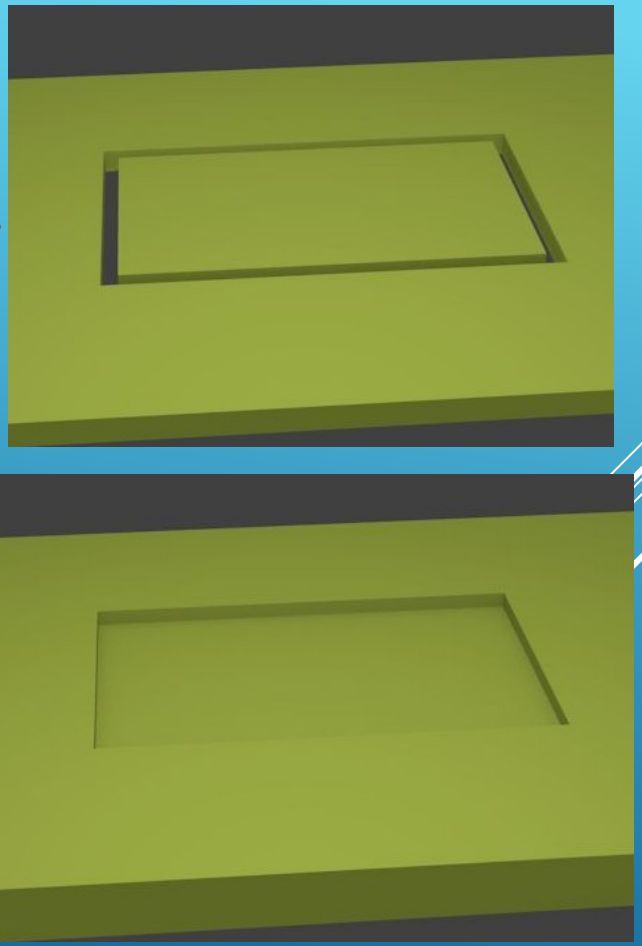
- CAD
  - Paid
    - Inventor
    - Solidworks
    - AutoCad
  - Free
    - Fusion360
    - OnShape
    - SketchUp
- CAM
  - Free
    - PyCAM

- Graphics
  - Paid
    - Adobe Illustrator
  - Free
    - Inkscape
- Misc.
  - Free
    - Blender
    - 123D Make

… or anything that can output vector shapes

3 MAIN CNC TOOLPATHS

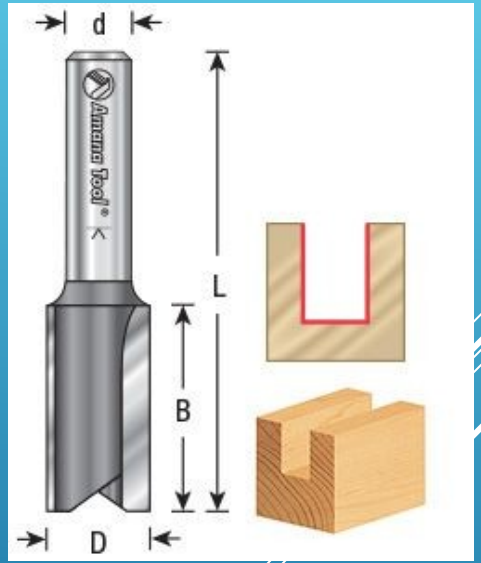
- **Profile** - cuts along a path
- **Pocket** - removes material over an area
- **Drill** - plunge down with no X-Y movement



CHOOSING THE RIGHT TOOL

End Mill properties

- Cutting diameter
- Shank diameter
- Nose shape: square, V, ball
- # of flutes (cutting surfaces)
- Flute shape: up/down spiral, straight, roughing
- Material



Example router bit
toolstoday.com

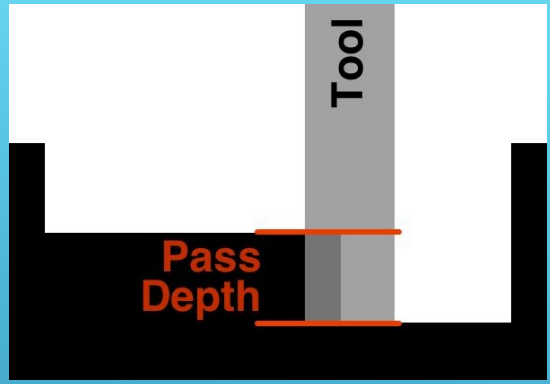
Good starting choice for wood:

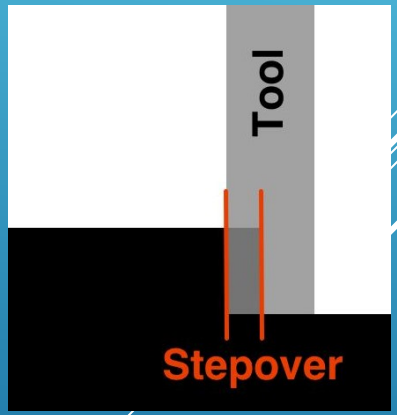
¼″ or ⅛″ square 2-flute straight bit

IMPORTANT CAM VARIABLES - CUTS

- **Pass depth** - Cut depth per pass
  - depth = bit diameter
- **Cut depth** - Total/final depth cut
- **Step over** - Distance between adjacent passes
  - Pocket cuts only
  - 40% of bit diameter

▶ All variables affect time and quality of job. Poor choices can cause tool wear or damage





IMPORTANT CAM VARIABLES - RATES

- **Spindle Speed** - RPM of tool (12000-24000 rpm)
- **Feed rate** - How fast does the tool move in X-Y?
- **Plunge rate** - How fast does the tool move in Z?
  - ~50% of Feed rate

Chip Load Calculators and **Chip Load Charts** can be found Online

CALCULATING FEED RATE

Chip Load * # Flutes * Spindle Speed = Feed Rate

Material removed per flute cut. Varies with material and cutter diameter.

Approx. values for wood:
⅛″ cutter: 0.005″
¼″ cutter: 0.01″

Start at ~12000 RPM

CALCULATING FEED RATE - EXAMPLE

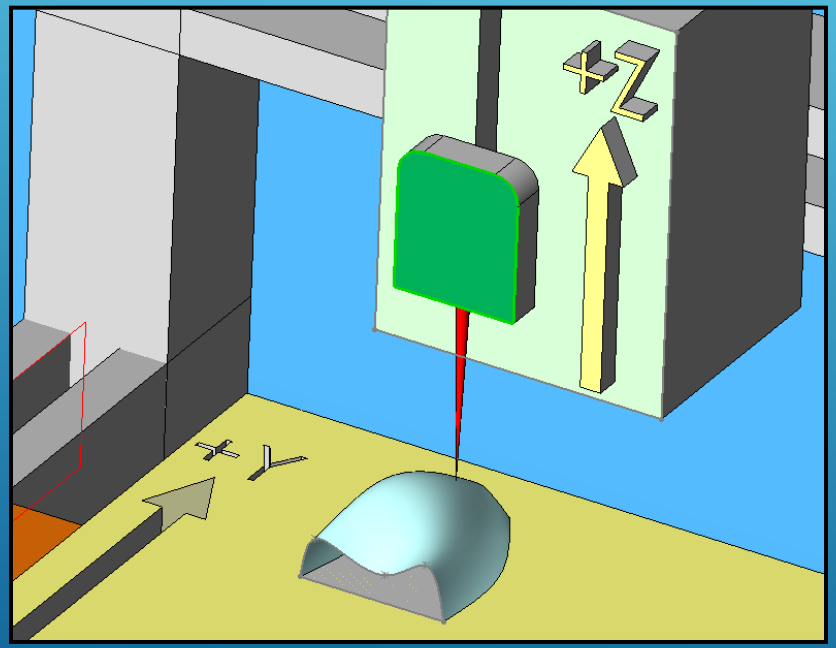
Cutting plywood with a ¼” 2-flute end mill

Chip Load * #Flutes * Spindle Speed

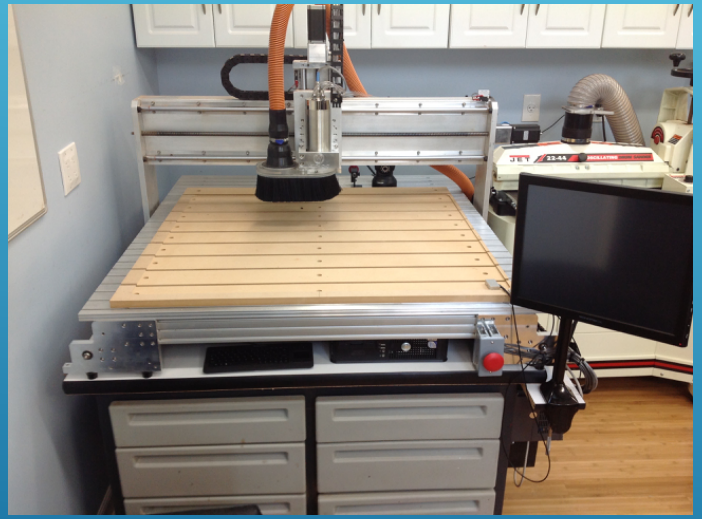
0.01” * 2 * 12000 RPM = 240 inches/minute maximum

Typical maximum feed rates vary from model to model.
100 Inches per Minute for Velox VR3636

CNC Scanning



MACHINE EXAMPLES

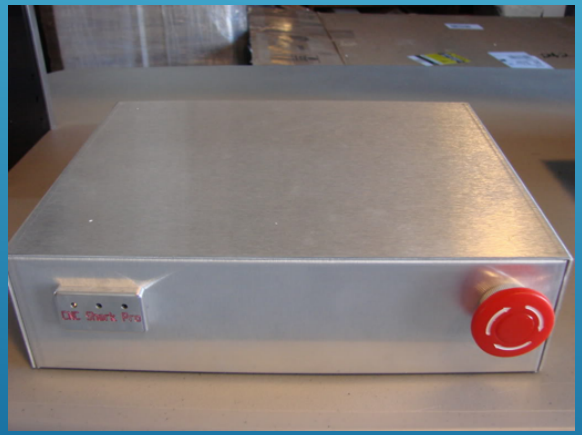


Velox VR3636

CNC Shark

Axiom

CONTROLLER EXAMPLES



External Box

Pendent

WOOD SIGN-PROCESS EXAMPLE

- STEPS INVOLVED IN CREATING A SIGN:
  - CREATING TEXT
  - INSERT SHAPES
  - SIZE AND ORIENT
  - TOOL PATHING
  - SIMULATION
  - CREATING MACHINE CODE

Let's Build Some Plaques

MY SHOP