CNC Router Operation & Production Using AltMill 4×4

Target Audience

This course is designed for beginners to intermediate users who wish to develop practical skills in CNC router operation using the AltMill 4×4 platform. It is suitable for makers, hobbyists, woodworkers, fabrication technicians, educators, students, prototype developers, and small-shop operators. Basic computer skills are required; no prior CNC experience is necessary. The course provides a structured progression from CNC fundamentals through CAD/CAM programming, machine setup, production workflows, maintenance, and troubleshooting, enabling learners to confidently operate and maintain the AltMill CNC router in professional and workshop environments.

Course Outcomes

Upon successful completion of this course, participants will be able to:

- Understand CNC routing principles and subtractive manufacturing processes.
- Identify the major mechanical and electronic components of the AltMill 4×4 CNC router.
- Apply safe operating procedures and workshop best practices.
- Select appropriate cutting tools for different machining applications and materials.
- Create basic CAD models suitable for CNC manufacturing.
- Generate efficient CAM toolpaths using Autodesk Fusion 360
- Configure machine coordinates, work offsets, and tool settings.
- Execute CNC machining operations safely and accurately.
- Optimize feeds, speeds, spindle parameters, and cutting performance.
- Evaluate machining quality and troubleshoot common CNC router issues.
- Perform routine maintenance, calibration, and preventive servicing.
- Prepare production-ready CNC jobs from design through finished component.

Course Objectives

- Build CNC fundamentals.
- Develop AltMill operational proficiency.
- Learn CAD/CAM workflows.
- Understand tooling and materials.
- Practice machine setup and production.
- Develop troubleshooting skills.

Course Outline

The course comprises **40** hours of theory and laboratory sessions and is divided into 10 different modules. Each module is followed by hands-on laboratory exercises.

Table of Contents

Module 1. Introduction to CNC Routing & AltMill Platform

- Fundamentals of CNC Routing
- CNC Router Applications Across Industries
- CNC Router vs CNC Milling Machine vs Laser Cutter
- Understanding Subtractive Manufacturing
- AltMill 4×4 Machine Architecture
- Machine Specifications and Working Envelope
- Linear Motion System (Ball Screws & Linear Rails)
- Closed-Loop Stepper Motors
- Spindle Types and Power Options
- Machine Coordinate System
- Work Coordinate System
- CNC Workflow Overview (CAD → CAM → Machine)
- Introduction to G-Code and Machine Operations

Module 2. Machine Components, Assembly & Safety

- Machine Structure and Mechanical Components
- Gantry, Bed, Spoilboard, and Frame
- Control Electronics Overview
- Emergency Stop and Safety Interlocks
- Limit and Homing Switches
- Cable Management
- Dust Collection Systems
- Spindle Cooling Options
- Router Installation and Alignment
- Daily Machine Inspection
- Workshop Safety Practices
- PPE Requirements
- Fire and Electrical Safety
- Material Handling Procedures
- Safe Startup and Shutdown Procedures

Module 3. Cutting Tools & Tool Management

- CNC Router Cutting Principles
- Collets, Nuts, and Tool Holders
- Router Bit Geometry
- Straight Bits
- Upcut Spiral Bits
- Downcut Spiral Bits
- Compression Bits
- Ball Nose Cutters
- V-Bits
- Surfacing Cutters
- Specialty Tools
- Tool Selection Based on Material
- Tool Wear and Tool Life
- Tool Inspection and Replacement
- Tool Storage and Maintenance

Module 4. Materials & Machining Fundamentals

- MDF
- Plywood
- Hardwood
- Softwood
- Acrylic
- Polycarbonate
- HDPE
- PVC
- Foam
- Composite Panels
- Aluminum (Light Machining)
- Material Behavior During Cutting
- Grain Direction and Tear-Out
- Workholding Techniques
- Vacuum Tables
- Mechanical Clamping
- Double-Sided Tape Methods
- Fixture Design Fundamentals

Module 5. Machine Operation & Controller Functions

- Power-Up Sequence
- Homing Procedure
- Manual Jogging
- Axis Movement
- Coordinate Display
- Setting Machine Zero
- Setting Work Offsets
- Tool Length Setting
- Controller Interface Overview
- Loading G-Code Files
- Feed Hold
- Resume
- Program Restart
- Feed Override
- Spindle Override
- Dry Run and Air Cutting
- Program Verification
- Safe Job Execution
- Job Completion and Shutdown

Module 6. CAD Fundamentals for CNC Routing

- CAD Workflow Overview
- Creating 2D Sketches
- Drawing Profiles
- Constraints and Dimensions
- Importing DXF and SVG Files
- Creating Multiple Parts
- Nesting Concepts
- Layer Management
- Design for CNC Manufacturing
- Exporting CAD Files for CAM

Module 7. CAM Programming Using Fusion 360 (or Equivalent)

- CAM Workspace Overview
- Tool Library Management
- Stock Definition
- Work Coordinate System Setup

- Toolpath Strategy Selection
- Facing Operations
- Pocket Operations
- Contour/Profile Operations
- Slot Machining
- Drilling Operations
- Engraving
- Chamfering
- Adaptive Clearing
- Tabs and Bridges
- Lead-In/Lead-Out
- Ramp Entry
- Rest Machining
- Simulation
- Collision Detection
- Post Processing
- G-Code Generation

Module 8. Feeds, Speeds & Cutting Optimization

- Fundamentals of Cutting Parameters
- Chip Load
- Feed Rate
- Plunge Rate
- Spindle Speed
- Step Over
- Step Down
- Material Removal Rate
- Optimizing Surface Finish
- Preventing Tool Breakage
- Avoiding Burning
- Eliminating Chatter
- Reducing Vibration
- Improving Dimensional Accuracy
- Optimizing Cycle Time

Module 9. Advanced CNC Router Operations

- Double-Sided Machining
- Indexing Techniques
- Multi-Tool Jobs

- Tool Changes
- Surfacing Large Spoilboards
- Fixture Plates
- Batch Production
- Repeatability and Production Setup
- Job Sequencing
- Production Efficiency
- File Management
- CNC Workflow Documentation

Module 10. Machine Maintenance, Calibration & Troubleshooting

- Daily Maintenance
- Weekly Maintenance
- Monthly Maintenance
- Cleaning Procedures
- Linear Rail Maintenance
- Ball Screw Lubrication
- Spindle Maintenance
- Collet Cleaning
- Checking Machine Squareness
- Axis Calibration
- Backlash Inspection
- Belt Inspection (if applicable)
- Dust Collection Maintenance
- Diagnosing Mechanical Problems
- Diagnosing Electrical Problems
- Lost Steps
- Homing Errors
- Surface Finish Issues
- Tool Breakage Analysis
- Preventive Maintenance Planning