FIRST EDUCATION

CNC Fabrication and Lean Manufacturing | Course Overview

Year-Long Course Outline with CTE Competencies

Equipment Requirements – CNC Lathe and or Mill

Course Description

In this course, students learn the fundamentals of CNC technology while developing hands-on skills with a CNC lathe and CNC milling machine. As a *FIRST* program, students have access to industry-recognized certifications through our sponsors, see the industry certifications page for these sponsorships. This curriculum serves as a professional pathway for students to gain workforce-ready skills while fulfilling essential technical roles on their *FIRST* Robotics Competition or *FIRST* Tech Challenge teams.

If instructors do not have immediate access to machines in their facility, they are encouraged to partner with a local community college or authorized testing center to provide students with hands-on certification opportunities.

Course Outcomes

COMPETENCY	STUDENT OUTCOMES
Apply Digital Fabrication (CAD/CAM) Workflows	Students will sketch parts in CAD and transfer geometry into toolpaths or machine code
Execute Safe CNC Machine Operation	Students will demonstrate mastery of safety features, including E-Stops and door interlocks, and identify personal protective equipment (PPE) requirements.
Implement Machine Setup & Start-Up Protocols	Students will perform pre-operation checks (coolant, cleanliness) and properly load workpieces using appropriate work-holding and clamping forces.
Interpret G-Code & CNC Control Functions	Students will analyze G & M codes for rapid vs. feed motion and navigate machine control layouts efficiently.
Apply Precision Measurement & Shop Math	Students will read blueprints (tolerances, title blocks) and utilize calipers and micrometers to inspect finished parts.
Manage Industrial Tooling & Materials	Students will select appropriate cutting tools and calculate machine speeds/feeds for common workpiece materials like aluminum and steel.
Apply Lean Manufacturing Principles (5S & Visual Management)	Students will implement 5S (Sort, Set in order, Shine, Standardize, Sustain) to organize CNC workstations and use visual signals (Andon) for machine status.
Execute Setup Reduction (SMED)	Students will apply Single-Minute Exchange of Die (SMED) techniques to minimize CNC machine downtime during tooling and fixture changeovers.
Perform Root Cause Analysis & Continuous Improvement	Students will use Kaizen and Plan-Do-Check-Act (PDCA) cycles to identify and eliminate waste (Muda) in fabrication workflows.
Implement Total Productive Maintenance (TPM)	Students will perform autonomous maintenance checks (lubrication, coolant levels) to prevent equipment failure and ensure process stability.
Standardized Work & Quality at the Source	Students will develop Standard Operating Procedures (SOPs) for part inspection and implement Poka-Yoke (Error Proofing) to ensure zero-defect manufacturing.

Industry Certifications

- Autodesk: Certified Associate CAD for Mechanical Design-Fusion
- OSHA: 10 Hour Safety Training
- Autodesk: Certified Associate in CAM for 2.5 Axis Milling
- Haas: Basic Mill Operator, Basic Lathe Operator,
- Mastercam: 2D Mill, 3D Mill, Lathe, Multiaxis, and Core

- SME: Lean Bronze Certification (Foundational for Lean practitioners)
- SME Additive Manufacturing Fundamentals Certification
- MSSC: Certified Production Technician (CPT) 4.0 (Covers Safety, Quality, Processes, and Maintenance)

FIRST Training learning content that can be used to implement this course.

FIRST Robotics Competition Trainings
FRC Virtual Kit of Parts
Module 2: How does *FIRST* Robotics Competitions Work?
Module 3: Intro to CAD and 3D Printing
Module 4: Fabrication Tools and Safety
Module 8: Design and Mechanical

Standards Alignments

Organization	Aligned Standards
NGSS	HS-ETS1-1, HS-ETS1-2, HS-ETS1-3, HS-ETS1-4, HS-PS3-3
ISTE	1.1.a, 1.1.c, 1.4.a, 1.4.b, 1.5.a, 1.5.b, 1.6.a
ITEEA (STEL)	1K, 2N, 3L, 4I, 5H, 6F, 7J, 8J, 9K
NIMS	Measurement Materials & Safety (MMS), CNC Milling (Operations), CNC Turning (Operations), Job Planning Benchwork & Layout, Quality & Continuous Improvement, Maintenance Awareness, Workforce Readiness
NBEA	Information Technology I.A, Communication III.A, Management III.A, Career Development I.B
ACTE-CRP	CRP1, CRP2, CRP4, CRP5, CRP6, CRP7, CRP8, CRP9, CRP10, CRP11, CRP12