



## PURPOSE

The purpose of this competition is to evaluate each competitor's skill to independently plan and program jobs and provide instructions for 5-Axis Computer Numerical Control (CNC) milling machine operators to execute. The competition also seeks to recognize outstanding students for excellence and professionalism.

## ELIGIBILITY

Open to active SkillsUSA members enrolled in programs with precision machining, automated manufacturing or CNC as an occupational objective.

## CLOTHING REQUIREMENTS

### **Class C: Competition Specific – Manufacturing/Construction Khaki Attire**

- Official SkillsUSA khaki short-sleeve work shirt
- Khaki pants
- Black, brown or tan work shoes

**Note:** Safety glasses must have side shields or goggles. (Prescription glasses may be used only if they are equipped with side shields. If not, they must be covered with goggles.)

These regulations refer to clothing items that are pictured and described at [www.skillsusastore.org](http://www.skillsusastore.org). If you have questions about clothing or other logo items, call 1-888-501-2183.

**Note:** Competitors must wear their official competition clothing to the competition orientation meeting. Safety glasses must be worn in the machine tool area.

## EQUIPMENT AND MATERIALS

Competitors may bring their own laptop with pre-installed CAM and verification software. Laptops will be provided to national competitors who elect not to use their own at the national competition. Note: laptops may NOT be provided to competitors in a local and/or state event. Be sure to check your state's competition updates for more information.

Competitors not using Fusion 360 or Mastercam software must bring their own laptop with their preferred CAM software pre-installed and are responsible for obtaining software license and post-processor(s) compatible with competition CNC machine(s).

1. Supplied by the technical committee:
  - a. CAD/CAM software (Fusion 360 or Mastercam) and verification software (Vericut).  
Use the links below to request software for training and practice in advance of the competition
    - 1). [Fusion 360](#)
    - 2). [Mastercam](#)
    - 3). [Vericut](#)
  - b. Software license for Mastercam and Vericut (Fusion 360 license/account must be requested in advance of the competition)
  - c. Laptops with pre-installed CAM software (Fusion 360 or Mastercam) and verification software (Vericut)
  - d. Standard wired mouse
  - e. Machinery's Handbook
  - f. Pencils and paper
  - g. NIMS Testing Center Account
2. Supplied by the competitor:
  - a. Wi-Fi enabled laptop with USB-A port or adapter and pre-installed CAM and verification software (laptop may be provided for national competitors)
  - b. Computer mouse (3-D mouse allowed)
  - c. Hand-held scientific calculator
  - d. All competitors must create a one-page resume. See "Resume Requirement" below for guidelines. Additionally, and as part of the competition, competitors must submit a hard copy of their resume during the mock interview portion of the competition.

### RESUME REQUIREMENT

Competitors must create a one-page resume to submit online. SkillsUSA South Carolina competitors should submit their resume by the deadline published on the competition updates page of our website. Failure to submit a resume will result in a 10-point penalty.

Your resume must be saved as a PDF file type using file name format of "Last Name\_First Name." For example, "Amanda Smith" would save her resume as Smith\_Amanda. If you need assistance with saving your file as a PDF, visit the Adobe website for more information.

Note: Check the Competition Guidelines and/or the updates page on the state website.

## **PROHIBITED DEVICES**

Cellphones, electronic watches and/or other electronic devices not approved by a competition's national technical committee are **NOT** allowed in the competition area. Please follow the guidelines in each technical standard for approved exceptions. Technical committee members may also approve exceptions onsite during the SkillsUSA Championships if deemed appropriate.

### **Penalties for Prohibited Devices**

If a competitor's electronic device makes noise or if the competitor is seen using it at any time during the competition, an official report will be documented for review by the Director of the SkillsUSA Championships. If confirmed that the competitor used the device in a manner which compromised the integrity of the competition, the competitor's scores may be removed.

## **SCOPE OF THE COMPETITION**

### **KNOWLEDGE PERFORMANCE**

The competition will include a written test to evaluate a competitor's knowledge of Computer Numerical Control 5-axis milling programming in such areas as: safety, materials, measuring and test equipment, applied mathematics, engineering drawings, geometric dimensioning and tolerancing, machine technologies, controls navigation, cutting tool and holder technologies, computer operations, and software technologies.

### **SKILL PERFORMANCE**

This competition will assess the ability to program CNC 5-axis milling machines, interpret prints (including GDT), and measure/gauge parts. Competitors also will demonstrate theoretical knowledge of CNC machine configuration, setup, and operations.

### **COMPETITION GUIDELINES**

1. Each competitor will be provided with the following technical documents to program a part using CAM software:
  - a. Programming instructions
  - b. Dimensional drawing and/or digital product definition data set
  - c. Solid models
  - d. Resource list (available CNC machine, part material, cutting tools, holders, and withholding devices)
2. Competitors demonstrate the following programming skills:
  - a. Document process plans
  - b. Create and/or modify solid models
  - c. Align and position models in CAM programming environment
  - d. Create 5-axis toolpaths
  - e. Simulate program in virtual machine environment

- f. Post process NC program file(s)
  - g. Create technical documentation
  - h. Troubleshoot G-code errors
3. Competitor submits:
    - a. NC program file(s)
    - b. Tool list(s)
    - c. Setup sheet(s)
    - d. Process plan
  4. Technical committee
    - a. Evaluates documents for required elements
    - b. Runs and scores the part using a simulation software
    - c. May run program on machine if simulation runs without safety violations, errors, or crashes
  5. Competitor demonstrates ability to inspect sample parts
  6. Competitor demonstrates ability to navigate CNC machine control to perform functions
  7. Competitors are given the opportunity to familiarize themselves with CNC machine, laptop, and software during orientation day with technical support experts on hand.

## **COMPETITION COMPONENTS**

The CNC competition is divided into five main components:

### **CAM Programming**

This component assesses a competitor's skills and knowledge in CNC programming. Competitors will use CAM software to program part features and generate NC file(s).

### **G-Code Troubleshooting**

This component assesses a competitor's skills and knowledge in manual coding. Competitors will troubleshoot G-code programming errors.

### **CNC Technology Exam**

This is a theoretical/written exam that assesses a competitor's knowledge in CNC technology.

### **Process Control Exam**

This component assesses a competitor's knowledge in quality control applications.

### **Employability**

Mock interview to assess competitor's skills in obtaining employment.

## **STANDARDS AND COMPETENCIES**

### **CNCX 1.0 — Process Planning: Formulate strategies to mill parts**

- 1.1. Practical
  - 1.1.1. Process plan parts
  - 1.1.2. Document process plans
- 1.2. Critical Thinking
  - 1.2.1. Select machine tools
  - 1.2.2. Select workholding devices and accessories

- 1.2.3. Select cutting tools and holders
- 1.2.4. Determine extension out of holders (EOH) and length of cut (LOC)
- 1.2.5. Determine process strategies
- 1.2.6. Determine machining strategies
- 1.2.7. Determine speeds and feeds

### **CNCX 2.0 — Modeling: Create and/or modify solid models Practical**

- 2.1. Create sketches as necessary for toolpath guidance and containment
  - 2.1.1. Modify existing solid models
  - 2.1.2. Mate or position solid models
- 2.2. Critical Thinking
  - 2.2.1. Verify models

### **CNCX 3.0 — Assembly Modeling: Create solid model assemblies**

- 3.1. Practical
  - 3.1.1. Mate solid model components
- 3.2. Critical Thinking
  - 3.2.1. Verify assemblies

### **CNCX 4.0 — Toolpath Creation: Create toolpaths to mill parts**

- 4.1. Practical
  - 4.1.1. Create 3+2 and synchronized 5-axis toolpaths
  - 4.1.2. Simulate toolpaths in the CAM software
  - 4.1.3. Post-process
- 4.2. Critical Thinking
  - 4.2.1. Determine potential machine collisions
  - 4.2.2. Determine tool axis positions
  - 4.2.3. Analyze cut parts for gouges
  - 4.2.4. Compare cut part against model

### **CNCX 5.0 — Coding: Write or edit G-code programs to machine parts or qualify workholding device accessories for machine setups**

- 5.1. Practical
  - 5.1.1. Manually write G-code to requalify workholding devices
  - 5.1.2. Edit existing G-code programs
- 5.2. Critical Thinking
  - 5.2.1. Debug syntax and program errors

### **CNCX 6.0 — Program Verification: Verify programs in a virtual environment**

- 6.1. Practical
  - 6.1.1. Simulate program in virtual machine environment
- 6.2. Critical Thinking
  - 6.2.1. Analyze cut parts for gouges
  - 6.2.2. Compare cut part against model
  - 6.2.3. Determine potential machine collisions

## **CNCX 7.0 — Documentation: Create technical documents required to communicate instructions required for machine operators to execute programs**

- 7.1. Practical
- 7.2. Create technical documents
- 7.3. Critical Thinking
- 7.4. Evaluate documents to ensure content and format clearly communicated instructions

## **CNCX 8.0 — SkillsUSA Framework**

The SkillsUSA Framework is used to pinpoint the Essential Elements found in Personal Skills, Workplace Skills and Technical Skills Grounded in Academics. Students will be expected to display or explain how they used some of these Essential Elements. Please reference the graphic, as you may be scored on specific elements applied to your project. For more, visit: [www.skillsusa.org/who-we-are/skillsusa-framework/](http://www.skillsusa.org/who-we-are/skillsusa-framework/).



*Source: NIMS CAM Milling Programmer Standards. For more information, visit: <https://www.nims-skills.org/machining-smart>.*

## **COMMITTEE IDENTIFIED ACADEMIC SKILLS**

The technical committee has identified that the following academic skills are embedded in this competition.

### **Math Skills**

- Use fractions to solve practical problems
- Simplify numerical expressions
- Apply Pythagorean Theorem
- Solve problems using proportions, formulas, and functions
- Solve problems using trigonometry
- Solve problems using Cartesian coordinate system

### **Science Skills**

None Identified

### **Language Arts Skills**

None Identified

## **CONNECTIONS TO NATIONAL STANDARDS**

State-level academic curriculum specialists identified the following connections to national academic standards.

### **Math Standards**

- Numbers and operations
- Algebra
- Geometry
- Measurement

- Problem solving
- Reasoning and proof
- Communication
- Connections
- Representation

*Source: NCTM Principles and Standards for School Mathematics. For more information, visit: <http://www.nctm.org>.*

### **Science Standards**

- Understands the sources and properties of energy
- Understands forces and motion
- Understands the nature of scientific inquiry

*Source: McREL compendium of national science standards. To view and search the compendium, visit: <http://www2.mcrel.org/compendium/>.*

### **Language Arts Standards**

- Students adjust their use of spoken, written and visual language (e.g., conventions, style, vocabulary) to communicate effectively with a variety of audiences and for different purposes
- Students use a variety of technological and information resources (e.g., libraries, databases, computer networks, video) to gather and synthesize information and to create and communicate knowledge
- Students use spoken, written and visual language to accomplish their own purposes (e.g., for learning, enjoyment, persuasion and the exchange of information)

*Source: IRA/NCTE Standards for the English Language Arts. To view the standards, visit: [www.ncte.org/standards](http://www.ncte.org/standards).*