



## **Advanced Manufacturing Essential Skills Profile**

This profile outlines the skills required for successful completion of this career program. Additional information is located on the Apollo Career Center website at: <https://apollocareercenterhs.com>.

### **Advanced Manufacturing Program Overview**

In Advanced Manufacturing, get ready to work with state-of-the-art equipment that allows you to complete the latest engineering projects. Take your ideas, designs, and sketches and translate them into real-life 3D designs, blueprints, and more. Students develop strong skills in this industry by using CAD, 3D Inventor, and various interactive simulation software, which leads them into a career pathway that may include CNC programmer, equipment repair technician, machine control technician, or production machinist. Students are also prepared to advance their education towards a prospective career in mechanical or industrial engineering.

### **Next Ready Skills**

Each career path requires a specific set of skills and abilities for success in the industry. It is recommended that students have, be developing, or be able to develop the skills/abilities listed below.

**Effective Communicator**

- Reads and clarifies job instructions, prints, and process sheets before starting work.
- Explains setup decisions (workholding, tooling, speeds/feeds, coolant) to a teammate or supervisor using correct machining terms.
- Documents measurements, offsets, and inspection results clearly in logs or digital forms.
- Uses respectful, safety-focused communication to stop work and report hazards, defects, or machine issues.
- Participates in team problem-solving discussions and gives or receives feedback to improve quality and efficiency.

**Critical Thinking**

- Translates a print into a step-by-step machining plan that includes tolerances, order of operations, and inspection points.
- Selects tools, workholding, and cutting parameters based on material, finish, tolerance, and machine capability.
- Identifies the likely cause of dimensional errors (tool wear, deflection, offsets, workholding, thermal growth) and adjusts the process safely.
- Uses measurement data (micrometers, calipers, indicators) to make go/no-go decisions and prevent scrap.
- Recognizes abnormal machine conditions (sound, vibration, heat, chip formation) and takes corrective action.

**Adaptable Navigator**

- Shifts between manual machining and CNC workflows as production needs change.
- Learns new controls, tooling systems, and inspection equipment, then applies updated procedures consistently.

	<ul style="list-style-type: none"> <li>• Adjusts to time pressure, schedule changes, and short-run jobs while maintaining accuracy.</li> <li>• Uses digital resources (CAD/CAM files, calculators, e-learning platforms) to solve shop problems efficiently.</li> <li>• Adapts setups for different materials (aluminum, steel, plastics) and different part geometries.</li> </ul>
<b>Accountable Employee</b>	<ul style="list-style-type: none"> <li>• Follows shop safety rules, PPE requirements, and lockout/tagout expectations without reminders.</li> <li>• Arrives prepared with required tools, maintains a clean work area, and practices 5S habits.</li> <li>• Performs required pre-operation checks, confirms machine readiness, and reports maintenance needs.</li> <li>• Protects quality by completing first-piece inspections, documenting results, and following rework procedures.</li> <li>• Demonstrates professional behavior, ethics, and respect for diverse coworkers and customer requirements.</li> </ul>
<b>Skilled Professional</b>	<ul style="list-style-type: none"> <li>• Uses precision measurement tools to verify size, geometry, and tolerance requirements.</li> <li>• Sets up and operates manual lathes and milling machines, selecting correct cutting tools, speeds/feeds, and coolant.</li> <li>• Plans and performs cutting, drilling, turning, milling, and grinding operations to meet print specifications.</li> <li>• Creates, edits, and runs CNC programs using standard G and M codes (and/or CAM output) with safe prove-out practices.</li> <li>• Verifies part quality, troubleshoots machining cells, and completes basic machine maintenance and tool care.</li> </ul>

### **Knowledge Required in Advanced Manufacturing**

<b>Knowledge Area</b>	Basic Mechanical Aptitude, Hands on approach to problem solving
<b>Mathematics</b>	Uses decimals, fractions, geometry, and basic trigonometry for layout, feeds/speeds, offsets, and tolerance calculations.
<b>Mechanical</b>	Understands machine components, tooling, lubrication/coolant systems, and how adjustments affect accuracy and surface finish.
<b>Production and Processing</b>	Follows process plans, prioritizes quality, reduces scrap, and understands how workflow impacts output and cost.
<b>Design</b>	Interprets prints, GD&T symbols as introduced, and uses CAD/CAM files or models to plan machining operations.

### **Advanced Manufacturing Activities**

<ul style="list-style-type: none"> <li>• Calculate dimensions or tolerances using precision instruments such as micrometers or vernier calipers.</li> <li>• Study sample parts, blueprints, drawings, or engineering information to determine the method and sequence of operations.</li> <li>• Set up, adjust, and operate machine tools to perform precision machining operations.</li> <li>• Machine parts to specifications using lathes, milling machines, shapers, or grinders.</li> <li>• Align and secure holding fixtures, cutting tools, attachments, accessories, or materials onto machines.</li> </ul>
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- Program computers or electronic instruments such as numerically controlled machine tools.
- Monitor the feed and speed of machines during the machining process.
- Check workpieces to ensure they are properly lubricated or cooled.
- Measure, examine, or test completed units to check for defects and conformance to specifications.
- Confer with numerical control programmers to ensure programs and equipment will function properly and meet specifications.
- Diagnose machine tool malfunctions to determine the need for adjustments or repairs.
- Maintain machine tools in proper operational condition.
- Fit and assemble parts to make or repair machine tools.
- Operate equipment to verify operational efficiency.
- Evaluate machining procedures and recommend changes for improved efficiency or adaptability.
- Lay out, measure, and mark metal stock to display placement of cuts.
- Design fixtures or tooling to meet special engineering needs.
- Dispose of scrap or waste material in accordance with company policies and environmental regulations.
- Separate scrap waste and related materials for reuse, recycling, or disposal.
- Confer with engineering, supervisory, or manufacturing personnel to exchange technical information.
- Set up or operate metalworking, heat-treating, welding, or cutting equipment as needed.
- Dismantle machines or equipment using hand or power tools to examine parts and replace defective parts.
- Install repaired parts into equipment or install new equipment.
- Support projects from planning and fabrication through assembly, inspection, and testing using knowledge of machine functions, metal properties, and mathematics.

### **Additional Pathways Considerations**

Programs in this pathway include additional recommendations for fully engaging with learning opportunities and earning industry credentials/certifications.

#### **Mathematical Skills**

Advanced manufacturing relies heavily on precise mathematical reasoning and measurement. Students regularly apply mathematics when interpreting blueprints, calculating dimensions, setting machine parameters, and verifying finished part tolerances. Students must be comfortable working with precise measurements and performing calculations accurately to ensure manufactured parts meet required specifications. Important mathematical skills include:

#### **Academic strengths**

- Measurement and precision calculations using thousandths of an inch (0.001") or metric equivalents
- Fractions, decimals, and conversions between measurement systems (fractional inch, decimal inch, metric)
- Geometry concepts such as angles, radii, diameters, arcs, and geometric relationships used in machining operations
- Trigonometry basics (sine, cosine, tangent) used for calculating angles, tool paths, and complex part dimensions
- Algebraic reasoning for calculating feed rates, spindle speeds, and machining parameters
- Tolerance calculations when determining acceptable variation in manufactured parts
- Ratio and proportion when scaling measurements or interpreting machine settings

- Basic statistics and quality measurements used in inspection and quality control processes

### **Reading and comprehension**

Students must be able to read and interpret technical information used in manufacturing environments. These materials often contain specialized vocabulary, symbols, and diagrams. Students must be able to extract accurate technical information from written documents to ensure equipment is operated safely and parts are produced correctly. Reading comprehension skills may include:

- Interpreting engineering drawings and blueprints, including dimensions, tolerances, and symbols
- Understanding machining process sheets and job instructions
- Reading technical manuals for machine tools and CNC equipment
- Interpreting tool charts and cutting data tables
- Understanding industry codes and manufacturing standards
- Reading safety procedures, OSHA regulations, and workplace policies
- Understanding Safety Data Sheets (SDS) for lubricants, coolants, and cleaning chemicals
- Following step-by-step machining procedures and setup instructions
- Interpreting CNC programming code and machine interface instructions

### **Writing and documentation**

Although manufacturing is highly technical, written communication is still an important part of the job. Workers must accurately document processes, measurements, and production information. Clear and accurate documentation helps maintain product quality, supports workplace communication, and ensures traceability in manufacturing processes. Writing and documentation skills may include:

- Completing work orders and production logs
- Recording measurement results during inspection and quality control
- Documenting machine setup procedures and adjustments
- Writing brief reports describing machining issues or defects
- Recording tool usage, maintenance activities, and machine conditions
- Completing safety reports or incident documentation when required
- Communicating production updates to supervisors or team members
- Entering data into digital manufacturing systems or quality tracking systems

### **Science and engineering concepts**

Advanced manufacturing applies several scientific principles, particularly in physics and materials science. Understanding these concepts helps students operate machinery safely and produce quality parts. Relevant science concepts include:

- Physics: Advanced manufacturing relies heavily on applied physics concepts such as force, motion, friction, and mechanical advantage. Students must understand how cutting tools interact with metal surfaces, how rotational speed affects cutting performance, and how heat is generated during machining processes.
- Material Science: Students learn how different materials (steel, aluminum, plastics, composites) respond to machining operations. Understanding hardness, ductility, and heat resistance helps machinists choose appropriate cutting tools and speeds.
- Thermal Concepts: Heat transfer and temperature management are important when machining metals. Coolants and lubricants are used to control heat and reduce tool wear.
- Mechanical Systems: Students apply concepts related to rotating machinery, mechanical power transmission, and machine tool operation.
- Chemistry: Basic chemistry concepts are relevant when working with cutting fluids, coolants, lubricants, and cleaning chemicals used in manufacturing processes.

### **Geometry and spatial awareness**

Manufacturing professionals must visualize three-dimensional objects and understand how individual dimensions interact within a part. Strong spatial reasoning supports accurate machining and quality inspection. Students who demonstrate strong spatial reasoning skills are often more successful when operating milling machines, lathes, and CNC equipment because they can better visualize how raw material will be transformed into finished components. Important spatial skills include:

- Visualizing three-dimensional objects from two-dimensional engineering drawings
- Understanding how parts are oriented within a machine tool
- Interpreting geometric dimensioning and tolerancing (GD&T) symbols
- Recognizing relationships between angles, surfaces, and part features
- Determining how material must be removed to achieve the desired shape
- Understanding coordinate systems used in CNC programming
- Mentally rotating objects to understand machining operations
- Recognizing how tool paths interact with workpieces during machining

### **Career expectations**

#### **Physical Demands**

- Standing and walking: commonly standing for most of the shift; frequent walking between machines, benches, and inspection stations.
- Hand use and fine motor control: continual use of hands for tool changes, measurement, deburring, and control adjustments.
- Lifting and carrying: lifting and moving raw stock, vises/chucks, fixtures, and finished parts; common lift range is 10-35 pounds, with occasional lifts up to about 50 pounds depending on the shop and part size.
- Postures and repetitive motion: repeated bending, reaching, and twisting; repetitive motions during production runs and inspection.

- Vision and hearing: strong near vision for reading graduations and seeing surface finish; ability to notice machine sounds indicating tool wear or unsafe conditions; hearing protection is commonly required.

**Work Environment**

- Primarily indoors, often in an environmentally controlled manufacturing facility; some areas may be warm near machines or heat-treat operations.
- Noise and vibration from running equipment; exposure to distracting or uncomfortable noise levels is common.
- Exposure to moving mechanical parts, sharp edges, hot chips, and occasional minor cuts or burns; strict machine guarding and safe practices are essential.
- Possible exposure to metalworking fluids, oils, solvents, and airborne contaminants (mist, dust); ventilation and PPE may be required.
- Work is performed around other employees at arm’s length or closer in shared machining and inspection areas.

**Job Tasks**

- Set up and operate manual lathes and mills: select workholding, set tool height/zero, square stock, and produce features to print.
- CNC workflow: load programs, set work offsets and tool length offsets, complete safe prove-out, and run production parts.
- Inspection: complete first-piece, in-process, and final inspections using micrometers, calipers, indicators, and gauges; document results.
- Troubleshooting: respond to alarms, tool wear, chatter, poor finish, and dimensional drift; make safe adjustments and communicate issues.
- Maintenance and housekeeping: clean machines, check fluids, handle chips/swarf, and complete basic preventative maintenance tasks.

**Work Schedules**

- Many positions are full time; some facilities operate around the clock and use 2nd/3rd shift schedules or weekend shifts.
- Overtime may occur to meet production deadlines; schedule may change during peak demand.
- Work is typically on-site; travel is uncommon for entry-level machinists unless supporting field repair or multi-site operations.

**Safety**

- OSHA awareness and shop safety training are standard expectations; many programs prepare students for an OSHA 10-hour General Industry credential.
- Personal protective equipment (PPE) commonly includes: ANSI-rated safety glasses with side shields; steel-toed safety shoes; hearing protection; task-appropriate gloves (as permitted around rotating equipment); face shield for grinding; protective sleeves/aprons as needed.

- Hazard awareness includes: rotating machinery and pinch points; flying chips and broken tools; sharp edges; hot surfaces; electrical hazards; coolant and chemical exposure; slip and trip hazards from chips and fluids; ergonomic lifting risks.
- Safety procedures may include: lockout/tagout (LOTO) when servicing equipment; safe use of GFCI-protected electrical tools; proper storage and disposal of hazardous materials; knowing locations of eyewash stations and emergency showers; correct fire extinguisher selection and use.
- Students must be able to read and follow Safety Data Sheets (SDS) and understand labeling and Right-to-Know expectations.
- Many employers require pre-employment drug screening and ongoing compliance with a drug-free workplace policy.

### Technology and Software

<b>Vendor/Platform</b>	<b>Software/Learning Management System / Use</b>
<b>Autodesk / Dassault / PTC (varies)</b>	CAD tools such as AutoCAD and 3D CAD for part visualization and print reading support.
<b>Mastercam / SolidCAM / OneCNC (varies)</b>	CAM software to generate toolpaths and post CNC code for mills and lathes.
<b>CNC Controls</b>	Machine control interface for offsets, tool libraries, alarms, and program execution.
<b>G-code and M-code standards</b>	Industry-standard CNC programming language for positioning and machining operations.
<b>Office Productivity</b>	Word, Excel, and PowerPoint for reports, logs, calculations, and presentations.
<b>Email and productivity tools</b>	Outlook or similar tools for communication, scheduling, and file sharing.
<b>CareerSafe / LMS platforms (varies)</b>	Online safety coursework and OSHA preparation (if used by the district/program).
<b>JobBOSS / SAP / ERP tools (varies)</b>	Production planning, job routing, and work order tracking in larger facilities.
<b>Digital inspection tools</b>	Digital calipers, micrometers, height gauges, and computerized measuring systems (as available).
<b>Additive manufacturing software (varies)</b>	STL conversion and slicer software used for basic additive manufacturing workflows.

### Industry Credentials/Certifications

Students can earn industry credentials/certifications while at Apollo Main Campus. Available accommodations are subject to vendor and/or State of Ohio approval. Some credential/certification exams do not allow any accommodations.

- OSHA 10-hour General Industry (recommended entry-level safety credential).
- NIMS (National Institute for Metalworking Skills) credentials aligned to measurement, job planning, CNC milling, and CNC turning (specific credentials vary by testing availability).
- MSSC Certified Production Technician (CPT) - foundational manufacturing credential covering safety, quality practices and measurement, manufacturing processes and production, and maintenance awareness.
- Additional options (program dependent): CAD/CAM user certificates, measurement and inspection micro-credentials, or industry-recognized machining skill assessments.

### **Post-Secondary Opportunities**

Apollo Career Center offers college credit courses in both academic and career technical programs.

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| College Credit Plus (CCP)                 | • The CCP program provides Ohio high school students an opportunity to complete college courses and earn transcribed credit.                                    |
| Career Technical Assurance Guides (CTAGs) | • CTAGs award college credit for career-technical coursework to students who complete an approved course and earn a qualifying score on the end-of-course exam. |
| Articulated Credit                        | • Some career-technical programs have agreements with colleges that allow students to earn credit toward a specific degree.                                     |

### **Possible Career Pathways**

<ul style="list-style-type: none"> <li>• CNC Programmer</li> <li>• Robotics Programmer</li> <li>• Robotics Repair Technician</li> <li>• General Machinist</li> <li>• Lab Technician Assistant</li> <li>• Equipment Repair Technician</li> <li>• Machine Control Technician</li> <li>• Production Machinist</li> <li>• Computer Numerical Control Programmer or Operator</li> </ul>	<p>With additional education:</p> <ul style="list-style-type: none"> <li>• Tool &amp; Die Maker</li> <li>• Mechanical Engineer</li> <li>• Industrial Engineer</li> </ul>
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