**NAAN MUDHALVAN – POLYTECHNIC – ODD SEMESTER 2025-26**

**COURSE CURRICULUM**

# CNC TURNING

## ABOUT THE COURSE

This practical course focuses on precision CNC turning operations using modern CNC lathes. Students will learn to perform external and internal turning, threading, grooving, chamfering, and contour profiling on metals like steel, aluminum, and brass. The program covers interpreting ISO drawings with GD&T, writing G-code, tool offset calibration, machine setup, quality inspection, and surface finishing. The students will engage in hands-on projects ranging from manufacturing bush-shaft assemblies to orthopedic pins, using industry tools like MasterCAM, FreeCAD, and FANUC CNC simulators. The course prepares students for real-world applications in aerospace, automotive, and medical industries.

| | |
|---|---|
| **COURSE NAME:** | CNC Turning |
| **TOTAL DURATION:** | 60 HRS |
| **MODE OF DELIVERY** | PHYSICAL CLASSROOM TRAINING AT RESPECTIVE COLLEGES |
| **TRAINER TO STUDENT RATIO:** | 1:60 |
| **TOTAL MARKS:** | 70 (External) + 30 (Internal) |

| **TABLE 1** | |
|---|---|
| **OVERALL COURSE OBJECTIVE** | Develop skilled CNC Turning operators capable of executing high-precision turning operations including external/internal machining, threading, tapering, and profiling on diverse materials, while integrating ISO-based drawing interpretation, G-code programming, safety compliance, and inspection techniques as per WorldSkills standards. |
| **LEARNING OUTCOME** | • Perform precise external and internal turning operations on cylindrical components using CNC turning machines.<br>• Execute threading, taper turning, grooving, and chamfering with accuracy on mild steel, aluminium, and brass.<br>• Interpret and apply technical ISO drawings to determine machining parameters and dimensional tolerances.<br>• Program CNC turning machines using G-code for multi-step machining including step turning, contouring, and threading.<br>• Set up CNC turning machines with appropriate tool offsets, work holding devices, and safety protocols. |

| | |
|---|---|
| | • Measure and verify dimensional accuracy and surface finish using micrometres, vernier callipers, and surface comparators.<br>• Perform surface finishing operations to achieve specified Ra values and aesthetic quality for various applications.<br>• Conduct routine maintenance, tool inspection, and troubleshooting to ensure uninterrupted machine performance.<br>• Apply batch production techniques with repeatability, quick changeover, and cycle time optimization.<br>• Demonstrate precision machining and fitting for assemblies including shafts, bushes, bolts, and threaded adapters. |

**TABLE 2: MODULE-WISE COURSE CONTENT AND OUTCOME**

| SL. NO. | MODULE NAME | MODULE CONTENT | MODULE LEARNING OUTCOME | DURATION (HRS) |
|---|---|---|---|---|
| 1 | CNC Turning Fundamentals | Introduction to CNC turning operations, safety procedures, and basic machine interface | Interpreting CNC turning machine operations, safety protocols, and basic setup procedures | 5 |
| 2 | External & Internal Turning | Machining cylindrical parts using facing, roughing, and finishing cycles | Perform precise external and internal turning operations to meet dimensional tolerances | 8 |
| 3 | Threading, Taper & Grooving | Toolpaths and cycles for threading, taper turning, grooving, and chamfering on various materials | Execute threading, taper turning, grooving, and chamfering on mild steel, aluminum, and brass | 8 |
| 4 | Technical Drawing & GD&T | Reading ISO-compliant technical drawings and understanding tolerances, fits, and GD&T symbols | Interpret ISO drawings and translate tolerances and symbols into machine parameters | 6 |
| 5 | G-code Programming | Writing and editing G-code for turning operations including contouring, threading, and profiling | Develop and simulate G-code programs for multi-step turning operations with accuracy | 7 |

| | | | | |
|---|---|---|---|---|
| 6 | CNC Machine Setup | Tool offset setting, workpiece clamping, machine referencing, and dry-run verification | Set up CNC turning machines with proper tool offsets, fixtures, and safety procedures | 5 |
| 7 | Measurement & Surface Finish | Using micrometers, vernier calipers, thread gauges; Ra measurement; inspection documentation | Measure and inspect machined parts for dimensional accuracy and surface finish | 5 |
| 8 | Surface Finishing Techniques | Polishing, deburring, chamfering, and knurling for aesthetic and functional finishing | Apply surface finishing techniques to meet required surface quality in industrial applications | 4 |
| 9 | Maintenance & Troubleshooting | Routine machine maintenance, tool condition checks, identifying and correcting common issues | Perform maintenance tasks and basic troubleshooting to ensure machine reliability | 4 |
| 10 | Batch Production & Fitting | Batch production practices, fast changeovers, and machining for assembly fits | Manage batch production and demonstrate precision turning for assembly components like bushes, shafts, bolts | 8 |

**TABLE 3: OVERALL COURSE LEARNING OUTCOME, ASSESSMENT CRITERIA AND USECASES**

| LEARNING OUTCOME | ASSESSMENT CRITERIA | USECASES |
|---|---|---|
| **1. Perform precise external and internal turning operations on cylindrical components using CNC turning machines.** | - Machined parts meet IT6–IT8 dimensional tolerances.<br>- Correct tool and parameter selection.<br>- Surface finish as per requirement.<br>- Safe machine operation followed. | - Manufacture a stepped shaft with multiple diameters.<br>- Turn a cylindrical bushing with precision bore.<br>- Create a precision pin with critical length and diameter tolerances. |

| | | |
|---|---|---|
| **2. Execute threading, taper turning, grooving, and chamfering with accuracy on various materials.** | - Thread profiles machined with correct pitch and depth.<br>- Taper angles within ±0.5°.<br>- Accurate groove/chamfer placement.<br>- Surface finish ≤ 1.6 µm in threaded areas. | - Create a bolt and nut pair with matching threads.<br>- Machine a tapered pin with chamfers.<br>- Turn a collar with groove and knurling. |
| **3. Interpret and apply technical ISO drawings to set machining parameters and tolerances.** | - Correct reading of dimensions, tolerances, and symbols.<br>- Conversion of drawings to process parameters.<br>- Understanding GD&T features. | - Analyse turning part drawings with tolerance stack-ups.<br>- Plan machining for shaft and collar.<br>- Identify critical fits from engineering drawings. |
| **4. Program CNC turning machines using G-code for multi-step machining.** | - Error-free programs with valid G/M codes.<br>- Proper use of threading and profiling cycles.<br>- Tool offsets and coordinate systems managed.<br>- Optimized cycle time. | - G-code for threaded shaft with contour profile.<br>- Simulation using NCViewer or TurnSim.<br>- Debug pre-written programs. |
| **5. Set up CNC turning machines with proper offsets and safety protocols.** | - Accurate tool offset input.<br>- Secure work holding.<br>- PPE and safety practices followed.<br>- Correct machine startup/shutdown. | - Calibrate offsets for batch production.<br>- Perform machine setup for precision job.<br>- Execute tool change and E-stop procedure. |
| **6. Measure and verify dimensional accuracy and surface finish.** | - Use of micrometres, verniers, thread gauges.<br>- Results within tolerance.<br>- Documentation maintained.<br>- Surface finish validated. | - Measure shaft diameters and threads.<br>- Inspect using comparators.<br>- Log inspection results. |
| **7. Perform finishing operations to meet surface and quality standards.** | - Surface roughness ≤ 0.8–1.6 µm.<br>- Use of appropriate finishing tools.<br>- Uniform finish across parts.<br>- No burrs/tool marks. | - Polish orthopaedic pins.<br>- Deburr automotive shafts.<br>- Finish aerospace fasteners. |
| **8. Perform maintenance and basic troubleshooting.** | - Tool wear inspection.<br>- Clean work area and machine. | - Replace worn inserts.<br>- Clean lathe post-shift.<br>- Diagnose chatter or misalignment. |

| | | |
|---|---|---|
| | - Identify and report faults.<br>- Apply basic corrections. | |
| **9. Apply batch production techniques.** | - Batches within dimensional limits.<br>- Efficient changeovers.<br>- Process consistency.<br>- Production data recorded. | - Run batch of custom fasteners.<br>- Switch tools for shaft types.<br>- Optimize repeat part production. |
| **10. Demonstrate precision machining for assembly fit.** | - Accurate fits (clearance/interference).<br>- Threads align correctly.<br>- Smooth assembly.<br>- Functional geometry ensured. | - Fit shaft and bush with interference.<br>- Assemble threaded pipe adapters with O-rings.<br>- Machine bolt/nut sets for fit test. |

| **TABLE 4: LIST OF FINAL PROJECTS (20 PROJECTS THAT COMPREHENSIVELY COVER ALL THE LEARNING OUTCOME)** | |
|---|---|
| **SL. NO.** | **FINAL PROJECT<br>(The Training Partner shall cover all the steps to complete a given project)** |
| 1 | Collar and Groove Flanged Pin with Accurate Dimensions and Surface Finish |
| 2 | Threaded Shaft with Precision Chamfering and Knurling for Enhanced Grip |
| 3 | Bolt and Nut Pair with Matching Thread Profiles and Assembly Fit Verification |
| 4 | Stepped Precision Shaft with External Threading and Multi-Diameter Turning |
| 5 | Roller Sleeve for General Manufacturing with Multi-Feature Turning and Inspection |
| 6 | Axial Stopper Pin with Centre Bore, Undercut Groove, and Polished Finish |
| 7 | Threaded Pipe Adapter with Internal and External Threads and Chamfered Edges |
| 8 | Re-machining and Refurbishment of Worn Shaft Including Keyway and Dimensional Restoration |
| 9 | Shaft and Bush Assembly Featuring Interference Fit with Dimensional and Finish Validation |
| 10 | Multi-Taper Profile Component with Smooth Radius Transitions and Surface Quality |
| 11 | Precision Gear Spindle with Tight Diameter Tolerances and Complex Profile Machining |
| 12 | Precision Camshaft Featuring Multiple Lobes, Threading, and Profiled Contours |
| 13 | PCD (Poly Crystalline Diamond) Bolt Pattern Shaft with Precision Face-Drilled Holes |
| 14 | Hydraulic Cylinder Piston Featuring Multi-Feature Turning Including Threading and Facing Finish |

| | |
|---|---|
| 15 | Magnetic Rotor Housing Consisting of Two-Part Press-Fit Assembly |
| 16 | Aerospace-Grade Nozzle Ring with High-Speed Facing Finish and Tight Tolerances |
| 17 | Custom Fastener Set Including Bolts, Nuts, and Spacers with CAD-Integrated Machining |
| 18 | Orthopaedic Bone Pin with Micro Turning, Surface Polishing, and Quality Compliance |
| 19 | Ejector Pin for Tool & Die Applications with Critical Dimensional and Surface Requirements |
| 20 | Dual-Diameter Shaft Incorporating Tapered Sections and Radius Finishing |

| **TABLE 5: COURSE ASSESSMENT RUBRICS (TOTAL MARKS: 70)** | | | | |
|---|---|---|---|---|
| **ASSESSMENT CRITERIA** | **DESCRIBE THE CRITERIA OF THE BELOW CATEGORY PERFORMANCE** | | | **TOTAL MARKS** |
| | **FAIR** | **GOOD** | **EXCELLENT** | |
| **Drawing Interpretation** | Misreads or omits key dimensions and tolerances; unable to apply drawing specifications. | Correctly interprets most dimensions and tolerances; applies with minor errors. | Accurately interprets all technical drawings and applies tolerances precisely. | 10 |
| **CNC Program Accuracy** | Contains errors; improper tool selection; incorrect cycles or missing steps. | Program runs with minor errors; cycles and tools mostly correct. | Error-free, optimized program using efficient toolpaths, offsets, and cycles. | 20 |
| **Machine Setup & Safety** | Poor tool offsets; insecure clamping; limited adherence to safety protocols. | Proper tool offset and workpiece setup; follows safety rules consistently. | Excellent setup precision; demonstrates full safety compliance and proactive safety checks. | 10 |
| **Turning Execution Quality** | Poor surface finish; missing or inaccurate features; improper sequence. | Acceptable surface finish with all features completed; minor quality issues. | High-precision machining; clean surface finish; all operations executed perfectly. | 10 |
| **Dimensional Accuracy** | Parts out of tolerance; inconsistent measurements. | Dimensions within specified tolerances with | All dimensions fall within IT6–IT8 limits; highly | 10 |

| | | | | |
|---|---|---|---|---|
| | | minor variation. | consistent across parts. | |
| **Surface Finish Evaluation** | Surface roughness exceeds target; visible tool marks or burrs. | Surface finish meets project specs; minor inconsistencies acceptable. | Uniform, smooth finish exceeding Ra targets; free of tool marks and burrs. | 10 |
| **TOTAL** | | | | **70** |

**Technical Specification**

| S.No. | Details | Specifications |
|---|---|---|
| 1 | Software/Tools used | • SOLIDWORKS<br>• FreeCAD - Latest<br>• CAMotics - Latest<br>• NCViewer - Web based<br>• LinuxCNC - Latest Stable<br>• MasterCAM (Trial/License) - v2023<br>• FANUC Manual Guide I – FANUC Simulator software |
| 2 | Kit(s) used | **CNC Turning Machine (Haas ST/Okuma LB Series)**<br>FANUC Control, Tailstock, Auto Tool Changer,<br>Chuck<br><br>**FANUC Simulator**<br>FANUC Manual Guide i, HMI Interface, CNC programming training setup<br><br>**Measurement Instruments Kit**<br>Micrometer, Vernier, Thread gauge, Comparator, Surface Roughness gauge<br><br>**Tooling Kit**<br>Tool holders, Inserts, Boring bars, Knurling tools, Threading tools<br><br>**Workholding Kit**<br>Soft Jaws, Fixtures, Chucks, Bushes<br><br>**Finishing Tools Kit**<br>Polishing wheels, Buffers, Surface roughness polishing tools |
| 3 | Total Kits available | • CNC Turning Machines - 10 Units<br>• FANUC Simulators - 15 Units<br>• Measurement Instrument Sets - 30 Sets<br>• Tooling Kits – 18 Sets<br>• Workholding Kits – 18 Sets<br>• Finishing Tools – 12 Sets |

| | | |
|---|---|---|
| 4 | No. of kits per batch | • CNC Turning Machines - 3 Machines per batch<br>• FANUC Simulators – 3 units per batch<br>• Measurement Instrument Sets – 10 Sets per batch<br>• Tooling Kits – 6 Sets per batch<br>• Workholding Kits – 6 Sets per batch<br>• Finishing Tools – 4 Sets per batch |
| 5 | Major Demonstration Kits | **Precision CNC Assembly Demo Setup**<br><br>Includes FANUC based CNC lathe, micrometer + roughness tester + bushing demo assembly<br><br>Demonstrates fit tolerances, surface roughness validation, threading, and assembly<br><br>Quantity used: 1-2 per session, reused in house |
| 6 | Certification | Joint certification by TNSDC and Penta CAD Technology |