STARK STATE COLLEGE

GENERAL SYLLABUS

Course Information

Course Name: Multiple Axis Programming
Course Number: ARL242

Required Materials

Textbook(s): Multiple Axis Programming Handbook Ariel Corp.
Required Readings: None
Additional Materials: Scientific Calculator, Laptops, Note Pads, Writing Utensils, Web Links, Handouts and related items as provided in class.

Course Outline/Calendar

The date of coverage and order of coverage may be modified based on the faculty member and events beyond the control of faculty members that interfere with class times and teaching.

Week	Chapter/Topic/Lab
1: Introduction to Multi-Axis Machining	• Course overview, safety protocols, and workshop procedures. • Review of 3-axis CNC machining concepts, G-codes, and M-codes. • Introduction to multi-axis machining: applications, benefits, and common terminology. • Explanation of the Cartesian coordinate system (X, Y, Z) and the additional rotary axes (A, B, C).
2: Understanding Multi-Axis Machine Kinematics	• Types of multi-axis machines: 4-axis, 5-axis, and multi-spindle machines. • Focus on 4-axis machine configurations and the introduction of rotary programming. • Explanation of workpiece setup, workholding devices (e.g., dovetail vises), and coordinate systems (WCS).
3: CAD/CAM Software Fundamentals	• Introduction to advanced CAD for multi-axis applications. • Software setup and configuration for multi-axis programming within a chosen CAM system (e.g., Mastercam, Fusion 360, NX). • Creation and modification of complex 3D solid models and wireframes.
4: Tooling and Speed/Feed Calculations	• Advanced tool selection for multi-axis machining, including special finishers like circle segment cutters. • Calculating appropriate speeds, feeds, and cutting depths for different materials and toolpaths. • Introduction to tooling libraries and managing tool data within the CAM software.
5: 4-Axis Rotary and Indexing	• In-depth programming for 4-axis machining, focusing on indexing and positioning. • Project: Simple engraving or machining on a cylinder using rotary axis indexing.
6: 3+2 Positioning (Fixed-Axis Machining)	• Introduction to 3+2 programming, where two rotary axes are locked into a fixed position. • Programming strategies for complex geometries with multiple setups. • Hands-on lab: Machining features on multiple faces of a block.

Week	Chapter/Topic/Lab
7: Toolpath Generation and Optimization (4-Axis)	• Creating multi-axis toolpaths using advanced CAM features. • Techniques for avoiding collisions and minimizing tool retraction movements. • Optimization of toolpaths to reduce cycle time and improve surface finish.
8: Project 1 – Complex 4-Axis Part	• Students apply learned skills to program and machine a complex part requiring 4-axis or 3+2 positioning. • Focus on efficient toolpath strategies and proper setup.
9: 5-Axis Machine Fundamentals	• Exploration of true simultaneous 5-axis motion and its benefits over 3+2 positioning. • Introduction to various 5-axis machine configurations (e.g., table-table, head-head). • Strategies for avoiding singularities and gimbal lock.
10: 5-Axis Toolpath Strategies	• Detailed study of 5-axis toolpaths, such as flowline and morph toolpaths. • Advanced techniques for complex surfacing and contoured parts. • Discussion of programming for complex industries (aerospace, medical).
11: Collision Detection and Verification	• Using CAM simulation and verification tools to check for errors and collisions. • Techniques for collision avoidance and handling clearance planes. • Hands-on lab: Simulating a complex 5-axis toolpath and identifying potential issues.
12: Machine Probing and Setup	• Instruction on using on-machine probes for automated part and tool setup. • Writing probing routines within the CAM software to automate fixture and tool offsets.
13: G-Code and Machine Control	• Post-processing and generating efficient, machine-specific G-code. • Manual G-code editing and advanced features. • Understanding and working with the specific CNC control panel.
14: Project2-5-Axis Machining	• Students program and machine a part using simultaneous 5-axis toolpaths, demonstrating mastery of complex setups and surface generation. • The project will incorporate probing and collision avoidance.
15: Optimization and Troubleshooting	• Refining toolpaths for maximum efficiency, improved surface finish, and longer tool life. • Advanced troubleshooting techniques for machine errors and program issues. • Consideration of advanced materials.
16: Course Review and Final Presentation	• Review of key multi-axis programming concepts and practical applications.Students present their final projects, explaining their programming methodology, toolpaths, and outcomes.Final assessment and course wrap-up.