A. **Course Description:** (Approved Catalog Description.)
   Survey of tooling and production activities adaptable to numerical control equipment and processes. Includes terminology, definitions and functions. Students will learn how to create part programs for CNC machinery.

B. **Related Program Outcomes:**
   a. An ability to apply knowledge of mathematics, science, and engineering
   b. An ability to design and conduct experiments, as well as to analyze and interpret data
   e. An ability to identify, formulate, and solve engineering problems
   f. An understanding of professional and ethical responsibility
   g. An ability to communicate effectively
   k. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

C. **Course Objectives:**
   Upon completion of the course the student will:
   1. Define the difference between accuracy and repeatability
   2. List and discuss the four basic phases of manufacturing
   3. Define X, Y, and Z axes on both vertical and horizontal CNC milling machines and lathes
   4. Discuss auxiliary axes and their designation on both vertical and horizontal machines
   5. Discuss how motion is transferred to the workpiece and spindle
   6. Define open and closed-loop control systems and discuss the differences
   7. Define point-to-point and contouring control systems and discuss the differences
8. Define and discuss the differences between incremental and absolute programming
9. Discuss different forms of program input media
10. Discuss the significance of different controller formats
11. Write and troubleshoot part programs for a CNC vertical milling machine and a horizontal lathe
12. Understand and apply the standard programming codes for the FANUC controller
13. Define and discuss tool length and cutter diameter offsets
14. Define and discuss a language-based computer programming system
15. Define and discuss a graphics-based (CAD/CAM) computer programming system
16. Define and discuss a postprocessor
17. Discuss the numerous cutting tools used with CNC equipment
18. Discuss the advantages and disadvantages of various cutting tool materials and designs
19. Calculate and apply the appropriate cutting feeds and speeds for various cutting tools and cutting tool materials.
20. Discuss various sound tooling practices
21. Discuss the various options for and applications of CNC fixturing
22. Define and discuss manufacturing cells and systems
23. Work with a team of 4-5 students to develop a cost estimate and price quotation to produce a series of parts to be manufactured and combined into an assembly for manufacture/sale
24. Give an oral presentation to a group on the quotation developed in #23 above

D. Course Outline:
   1. History of numerical control (NC), what is NC
   2. how NC and CNC operate, speed and feed selections and calculations
   3. NC data communication, M and G codes
   4. Part programming
   5. NC functions and features
   6. NC lathe tool radius, lathe axes, thread cutting
   7. CNC machining centers
   8. Isometric sketching of arcs and circles
   9. Language and graphics based programming
   10. Tooling for NC machines
   11. Advanced NC applications
   12. NC production plant tour
   13. Discussion of lathe programming including canned cycles, tool radius offset, speeds and feeds
   14. Discussion of sample lathe program
   15. Introduction of final project and selection of teams
16. How to cost a product for manufacture and sale including scrap rates, blank sizes, labor rates, assembly, tolerances, quality, sales costs

17. Presentation of a proposal to management

E. **Suggested Laboratory Topics/Projects:**

1. Drilling holes with a vertical mill
2. Making a series of linear cuts with cutter radius offset
3. Combining separate shorter programs into a larger program of multiple components
4. Making internal cuts versus external cuts
5. Considerations necessary for cutting a series of pockets with consideration for the entrance and exits angles and how they affect one another
6. Calculations necessary to program angles such as a regular pentagon
7. Students design and cut a part involving arcs with cutter offset
8. Cutting a radiused part on the lathe with canned cycles
9. Students design and cut a part with cutter offset, arcs, canned cycles, tapers on the lathe