A) COURSE

Course Id:	Course
5631	Numerical Computer Control

Class Hours per Week	Lab hours per week	Complementary practices	Credits	Total hour course
3	2	3	8	48 hrs. theory 32 hrs. Lab 80 hrs. total

B) GENERAL COURSE INFORMATION:

	EE (IEA)	ME (IM)	MME (IMA)	EME (IME)	MTE (IMT)
Level:	N.A.	VIII	X	X	IX
Course Type (Required/Elective)		Elective	Required	Required	Required
Prerequisite Course:		Manufacturing processes III (5626)	Manufacturing processes III (5626)	Manufacturing processes II (5504)	Manufacturing processes III (5504)
CACEI Classification:		IA	IA	IA	IA

C) COURSE OBJECTIVE

At the end of the course, the student will be capable of:
Know , operate and program in numerical controled machine tools , as well as have a number of basic concepts of machining , to apply the language and be able to make a CNC program . All this of course without forgetting the knowledge of origins , benchmarks , and especially control of cutting tools ; that may lead to the design of a piece by this process of Advanced Manufacturing

D) TOPICS (CONTENTS AND METHODOLOGY)

1.- Technology CAD-CAM - CNC		2 horas
Specific goal:	Students will learn the principles of CAD -CAM	
1.1 What is the computer-aided design ? 1.2 What is the computer-aided manufacturing ? 1.3 What is the computerized numerical control? 1.4 What is a postprocessor ? 1.5 Coordinate systems and motion of a CNC machine		
Readings and other resources	see bibliography	
Teaching methods	Driving deliberations , presentation	

Learning activities	Readings , practices

2.- CNC simulators		**2 hours**
Specific goal:	Students will learn the principles of CNC simulators.	
2.1 What is simulation? 2.2 Advantages and disadvantages of CNC simulation 2.3 Key functions of the CNC simulator 2.4 Steps to turn on the computer simulator		
Readings and other resources	Laboratory practice, see bibliography	
Teaching methods	Driving deliberations , presentation, monitoring practices	
Learning activities	Class exercises, lectures, practices, tasks	

3.- CNC programming (milling and turning)		**6 hours**
Specific goal:	Students will learn the fundamental concepts for turning and milling CNC.	

3.1 Fundamental Geometrical Principles
- 3.1.1 Coordinate System Machine
- 3.1.2 System based coordinates
- 3.1.3 Coordinate Systems Part
- 3.1.4 Allocation Machine coordinate system / workpiece coordinate system

3.2 Fundamentals of NC programming
- 3.2.1 Structure of an NC program DIN 66025
- 3.2.2 Language Elements
- 3.2.3 Program Structure

3.3 Elements of language
- 3.3.1 Gear Instructions (instruction - G)
- 3.3.2 Addresses
- 3.3.3 Instructions for racing, zero points and planes
- 3.3.4 machine Instructions (instruction - M)

3.4 Notes on tour
- 3.4.1 Programming the absolute measure (G90)
- 3.4.2 Programming the incremental measurement (G91)
- 3.4.3 Indication of metric / inch measurement (G70, G71)
- 3.4.4 Landslides zero (G54-G58) 3.4.5 Selection of working plane (G17-G19)

3.5 Path instructions
- 3.5.1 Movement rapid traverse G0
- 3.5.2 Interpolation of the straight line G1
- 3.5.3 Interpolation circle G2, G3
- 3.5.4 Instructions manners march
- 3.5.5 Tool radius corrections G40, G41, G42

3.6 Regulation of progress and movement of the spindle
- 3.6.1 Address F 3.6.2 Progress in mm / min G94
- 3.6.3 Progress in mm / rev G95
- 3.6.4 Address S
- 3.6.5 Direction of rotation of spindle M3, M4
- 3.6.6 Constant cutting speed G96, G97
- 3.7 Tools
- 3.7.1 Address T
- 3.7.2 Tool offsets

Readings and other resources	see bibliography
Teaching methods	Driving deliberations , presentation, monitoring practices.
Learning activities	Class exercises, lectures, practices, tasks

4.- Milling programming		**8 hours**
Specific goal:	Students will learn the necessary codes in numerical control milling	

4.1 Distribution in groups and states of implementation of the g functions
- 4.1.1 Rapid traverse G00
- 4.1.2 Linear interpolation G01. Examples Absolute programming and incremental programming
- 4.1.3 G02 Circular interpolation clockwise. Examples in absolute programming and incremental programming
- 4.1.4 Circular interpolation G03 in the anti clockwise. Examples in absolute programming and incremental programming
- 4.1.5 G04 Timeout
- 4.1.6 G17Plane change
- 4.1.7 M17 Reverse Order
- 4.1.8 unconditioned jump goto b / f
- 4.1.9 Tool path correction
- 4.1.10 G40 suppression toolpath correction
- 4.1.11 G41 Tool path correction on the left
- 4.1.12 G42 Tool path correction right
- 4.1.13 edge radius compensation. Turning radius compensation edge
- 4.1.14 Shift datum shift register G54-G58 position Programming
- 4.1.15 mm G71 4.1.16 Absolute programming G90
- 4.1.17 incremental programming G91
- 4.1.18 Indication of progress in mm / min (1/100 inch / min) G94
- 4.1.19 Indication of progress in mm / rev (1/10000 inch / rev) G95
- 4.1.20 Constant cutting speed G96
- 4.1.21 Direct programming of the speed of rotation G97
- 4.1.22 Limiting rotational speed G96 lims
- 4.1.23 Types of cycles Milling plane Cycle 71 Cycle 72 Contour Milling Pocket 1 rectangular recess Pocket 2 circulate casing Cycle 81 focused drill Cycle 84 Tapping without compensating plate

4.2 Distributions group and state of implementation of the functions M
- 4.2.1 M00 intermediate stop scheduled
- 4.2.2 M03 Main spindle clockwise connected
- 4.2.3 M04 Main spindle connected counterclockwise
- 4.2.4 Stopping the main spindle M05
- 4.2.5 M08 Coolant connected
- 4.2.6 M09 Coolant offline
- 4.2.7 M17 End of subprogram
- 4.2.8 M19 exact Paro main spindle
- 4.2.9 M30 End of program with return to the beginning of the program
- 4.2.10 M38 connected exact Paro
- 4.2.11 M39 offline exact Paro
- 4.2.12 M50 Disable steering logic
- 4.2.13 M51 Activate steering logic
- 4.2.14 Functions reflection
- 4.2.15 Reflection contour elements M90
- 4.2.16 Deactivating reflection
- 4.2.17 M91 Reflection on the X axis
- 4.2.18 M92 Reflection on the Y axis
- 4.2.19 M93 Reflection in the X and Y axel

Readings and other resources	see bibliography
Teaching methods	Driving deliberations , presentation, monitoring practices.
Learning activities	Class exercises, lectures, practices, tasks

5.- Lathe programming	**8 hours**
Specific goal:	The student will know the codes needed for turning in numerical control

5.1 Functions G

5.1.1 Rapid traverse G00
5.1.2 Linear interpolation G01. Examples in absolute programming and incremental programming 5.1.3 G02 Circular interpolation clockwise. Examples in absolute programming and incremental programming
5.1.4 Circular interpolation G04 in the anti clockwise. Examples in absolute programming and incremental programming
5.1.5 G04 Timeout
5.1.6 Calling subroutines
5.1.8 M17 Reverse Order
5.1.9 unconditioned jump goto b / f
5.1.10 Correction tool path 5.1.11 G40 suppression correction tool path
5.1.12 G41 Correction tool path on the left 5.1.13 G42 Correction tool path right
5.1.14 edge radius compensation. Turning radius compensation edge
5.1.15 Shift datum shift register G54-G58 position
5.1.16 inches G70 Programming
5.1.17 Programming in mm G71
5.1.18 Absolute programming G90
5.1.19 incremental programming G91
5.1.20 Indication of progress in mm / min (1/100 inch / min) G94
5.1.21 Indication of progress in microns / rev (1/10000 Inch / rev) G95
5.1.22 Constant cutting speed G96
5.1.23 Direct programming of the speed of rotation G97
5.1.24 Limiting rotational speed G96 lims
5.1.25 Types of cycles
-grooving cycle CYCLE93
-cilindrado cycle CYCLE95
-threading cycle CYCLE97
-drilling cycle CYCLE83
-centered bore CYCLE81
-tapping without compensating plate CYCLE84

5.2 Distributions group and state of implementation of the functions M

5.2.1 M00 intermediate stop scheduled
5.2.2 M03 spindle clockwise connected
5.2.3 M04 spindle counterclockwise connected
5.2.4 Main spindle stop M05
5.2.5 M08 refrigerant connected
5.2.6 M09 Coolant OFF 5.2.7 M17 end of subprogram
5.2.8 M20 delayed counterpoint
5.2.9 M21 counterpoint advance
5.2.10 M23 delayed collection tray
5.2.11 collection tray forward M24
5.2.12 M25 open the fastener
5.2.13 M26 close the fastener
5.2.14 M30 end of the program back to the beginning of the program
5.2.15 exact stop connected SPCON
5.2.16 exact stop SPCOF offline

Readings and other resources	see bibliography
Teaching methods	Driving deliberations , presentation, monitoring practices.

Learning activities	Class exercises, lectures, practices, tasks

6.- Overview Sinumerik 840D		**2 hours**
Specific goal:	Students will learn the programming language	
6.1 Instructions for developing a CNC program in the CNC board simulator 6.2 Simulation Exercises 6.3 Part programming Practices " gross " , CNC and CAD / CAM programming		
Readings and other resources	see bibliography	
Teaching methods	Driving deliberations , presentation, monitoring practices.	
Learning activities	Class exercises, lectures, practices, tasks	

7.- General Overview of Sinumerik 840D		**2 hours**
Specific goal:	Students will learn the commands and controls the location of the machine.	
7.1 Control Panel 7.1.1 Area control machine 7.1.2 Control Parameter Area 7.1.3 Area control program 7.1.4 Area control service 7.1.5 diagnosis command area 7.1.6 Input correction tools 7.1.7 Input zero offset 7.1.8 Input and management program 7.1.9 Test program		
Readings and other resources	see bibliography	
Teaching methods	Driving deliberations , presentation, monitoring practices.	
Learning activities	Class exercises, lectures, practices, tasks	

8.- Machine operation (milling, lathe)		**8 hours**
Specific goal:	Students will learn the basic commands for managing computer numerical control.	
8.1 Technical data Machine 8.2 Turning the Machine 8.3 Off Your Computer 8.4 Reference axis 8.5 Axes Operation 8.6 Spindle 8.7 Load tools 8.8 Changing tools 8.9 Mounting the clamping device 8.10 Safety Recommendations		
Readings and other resources	see bibliography	
Teaching methods	Driving deliberations , presentation, monitoring practices.	
Learning activities	Class exercises, lectures, practices, tasks	

9.- Setting up equipment (milling , lathe)		**8 hours**
Specific goal:	Students will learn to calibrate the numerical control equipment. .	
9.1 Tool Management : Create tool and load it into the warehouse 9.2 Correction Tool : calculate the lengths of the tool 9.3 Calculation of offset : mounting the workpiece and establish zero work		
Readings and other resources	see bibliography	
Teaching methods	Driving deliberations , presentation, monitoring practices.	
Learning activities	Class exercises, lectures, practices, tasks	

10.- Manage and run programs		**2 hours**
Specific goal:	The student will develop the machining of a part from drawing to manufacturing , including calibration tool	
10.1 Create NC program 10.2 Simulating the program for validation 10.3 Load , release , select and run the program 10.4 Project: development of a piece from a CNC manufacturing process , using simulators available .		
Readings and other resources	see bibliography	
Teaching methods	Driving deliberations , presentation, monitoring practices.	
Learning activities	Class exercises, lectures, practices, tasks	

E) TEACHING AND LEARNING METHODOLOGIES

Statement of the issues by the teacher. exhibition of subjects by using the teaching tools cnc simulation technology topics : 1,2 and 6 to 10 . Development of research work , CNC programming exercises by students , where they integrate knowledge acquired in the classroom for performance in laboratory practice manufacturing process simulation CNC using any available simulator mentioned in the bibliography .

F) EVALUATION CRITERIA:

Evaluation:	Schedule	Suggested Form of Evaluation and weighing	Topics
1st . Partial evaluation	session 16	**33 % Overall Rating** Partial Evaluation : • Written exam and / or computer : 80 % • Tasks and activities: 20 %	Unit 1 to 3
2nd Partial Evaluation	session 32	**33 % Overall Rating** Partial Evaluation : • Written exam and / or computer : 80 % • Tasks and activities: 20 %	Unit 4 to 6
3rd . Partial evaluation	Session 48	**33 % Overall Rating** Partial Evaluation : • Written exam and / or computer : 30 %	Unit 7 to 10

		• Project class : 50 % • Tasks and activities: 20 %	
Final Ordinary evaluation		100 % (Average Partial Ratings)	
Other activity:	Laboratory includes : CNC With activities specified in the corresponding Manual .		
Extraordinary exam	Week 17 of the semester	100% Exam	100% agenda
According to exam	According to schedule school secretary	100% Exam	100% agenda
Regularization exam	According to schedule school secretary	100% Exam	100% agenda

Ordinary Exam	100 % (Average Partial Ratings)
Extraordinary exam	Theoretical examination contents of the three units 50 % road test laboratory where proper use and handling of equipment is established: 50 %
According to exam	Theoretical examination of the three units contained 100 % I have passed the laboratory requirement concerning the course .
Regularization exam	Theoretical examination of the three units contained 100 % I have passed the laboratory requirement concerning the course.
Other academic activities required	Laboratory practices.

G) BIBLIOGRAPHY AND ELECTRONIC RESOURCES

Basic texts

THYER, G. E. *COMPUTER NUMERICAL CONTROL OF MACHINE TOOLS*. ELSEVIER, 2014.

SMID, PETER. *CNC PROGRAMMING HANDBOOK*. INDUSTRIAL PRESS, 2007.

VALENTINO, JAMES; GOLDENBERG, JOSEPH. *INTRODUCTION TO COMPUTER NUMERICAL CONTROL (CNC)*. ENGLEWOOD CLIFFS: PRENTICE HALL, 2003.

SEAMES, WARREN S. *COMPUTER NUMERICAL CONTROL: CONCEPTS AND PROGRAMMING*. CENGAGE LEARNING, 2001.

Complementary texts

SMID, PETER. *CNC PROGRAMMING TECHNIQUES*. INDUSTRIAL PRESS, 2006.

KRAR, STEPHEN F.; GILL, ARTHUR; SMID, PETER. *COMPUTER NUMERICAL CONTROL SIMPLIFIED*. INDUSTRIAL PRESS INC., 2001.

CHILDS JAMES F., PRINCIPLES OF INDUSTRIAL NUMERICAL CONTROL.
PATTON WILLIAM, NUMERICAL CONTROL, PRACTICE AND APPLICATION. RESTON PUBLISHING COMPANY INC., 1982.

- **Internet sites**

  http://tocs.ulb.tu-darmstadt.de/200101463.pdf

  ICT and CNC simulators used in teaching and learning.
  .
  http://www.emco-world.com/en/products/industrial-training/softwarecontrols/cat/31/d/1/p/31.html

  https://www.mastercam.com/en-us/
  http://www.hsmworks.com/
  http://www.surfcam.com/
  http://www.delcam.com/es/

- **Data base**

  http://www.delcam.tv/LZ/