GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2023 (COGC-2023)
Semester-VI

Course Title: CNC Machines
(Course Code: 4362005)

Diploma programmer in which this course is offered	Semester in which offered
Mechatronics	Sixth

1. RATIONALE

In the dynamic landscape of modern manufacturing, the utilization of advanced technologies is pivotal for success. The paradigm shift in the manufacturing environment necessitates the production of high-quality components within compressed timelines. With the evolution of information technology and the emergence of various manufacturing concepts emphasizing zero lead time and heightened quality standards, the rapid integration of computerized numerical control (CNC) machines has become imperative. Much like the increasing significance of mental acuity over physical prowess in human endeavors, CNC programming has gained paramount importance in conjunction with the selection and application of CNC tooling. This course is meticulously designed to equip students with the essential skills for CNC machine programming, tooling, and related aspects. It is noteworthy that CNC machines extend beyond conventional machine tools, permeating various facets of manufacturing processes and support activities. Given the expanding influence of CNC technology across diverse manufacturing domains, mechatronics engineers are presented with a unique opportunity to master these advanced techniques. The course aims to empower students to navigate the complexities of CNC technology, thereby preparing them to meet the challenges and opportunities presented by the contemporary manufacturing landscape.

2. COMPETENCY

The course content should be taught and curriculum should be implemented with the aim to develop required skills in the students so that they are able to acquire the following competency:

- Precision Programming and Operation
- Tooling Selection and Optimization
- Automation Proficiency
- Preventive Maintenance and Troubleshooting
- Process Optimization and Continuous Improvement

5. COURSE OUTCOMES (COs)

Theoretical concepts will be delivered, and practical sessions will be conducted in a manner that enables students to achieve the desired learning outcomes across cognitive, psychomotor, and affective domains, thereby demonstrating the following course outcomes.:

CO-1	Recognize various axes, machine zero, home position, systems, and controls of CNC machines.
CO-2	Choose, install, and configure cutting tools and tool holders on CNC machines
CO-3	Develop part programs using the ISO format for simple components, incorporating MACRO, CANNED CYCLE, and SUBROUTINE as needed.
CO-4	Utilize software applications for automated part programming
CO5	Implement maintenance procedures for CNC machines

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P/2)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	
3	0	2	4	70	30	25	25	150

Theory CA having 30 marks has two components, i.e., the micro-project assessment, which will be done out of 10 marks to facilitate the integration of COs. The remaining 20 marks would be the average of marks of the 2 mid-semester exams to be taken during the semester to assess the cognitive domain's attainment.

Legends: L-Lecture; T— Tutorial/Teacher Guided Theory Practice; P -Practical; C — Credit, CA- Continuous Assessment; ESE -End Semester Examination.

5. SUGGESTED PRACTICAL EXERCISES:

The practical should be properly designed and implemented with an attempt to develop different types of skills (outcomes in psychomotor and affective domain) so that students are able to acquire the competencies/programme outcomes. Following is the list of practical exercises for guidance. Note: Here only outcomes in psychomotor domain are listed as practical. However, if these practical are completed appropriately, they would also lead to development of certain outcomes in affective domain which would in turn lead to development of Course Outcomes related to affective domain. Thus, over all development of Programme Outcomes (as given in a common list at the beginning of curriculum document for this programme) would be assured.

Sr. No.	Unit No.	Practical Exercises (outcomes in Psychomotor Domain)	Approx. Hours

			Required
1	I,II	Preparatory activity: a. Collect mechanical components manufactured on CNC machines and show difference compared to conventional machining b. Identify operations on that components c. Prepare conventional process plan for at least two components.	02
2	III	Demonstrate constructional features and modes of operations of CNC.	02
3	III	Demonstrate and interpret CNC controllers features.	02
4	III	Demonstrate inserts, holders and tool management systems.	02
5	IV	Develop and simulate CNC turning part program (at least five) and identify errors and manufacture on CNC turning machine.	10
6	IV	Develop and simulate CNC milling part program (at least three) and identify errors and manufacture on CNC milling machine	06
7	IV	Prepare part program with CAD/ CAM software (like master cam, NX) and interface with CNC machine.	04
Total Hours			**28**

Notes:

a. It is compulsory to prepare log book of exercises. It is also required to get each exercise recorded in logbook, checked and duly dated signed by teacher.PA component of practical marks is dependent on continuous and timely evaluation and submission of exercises.

b. Term work report must not include any photocopy / ies, printed manual/pages, litho, etc. It must be hand written / hand drawn by student only.

c. Mini project and presentation topic/area has to be assigned to the group of specified students in the beginning of the term by batch teacher, if applicable.

d. For practical ESE part, students are to be assessed for competencies achieved. They should be given experience/part of experience to perform.

Sr. No.	**Sample Performance Indicators for the PrOs**	**Weightage in %**
Experimentation/performance type PrOs (PrOs Number: 2,3,4,5,6,7,8,9,10 &11)		
1	Knowledge	30
2	Quality of Report	30
3	Participation	20
4	Punctuality	20
Total		**100**
For Demonstration type PrOs (PrOs Number: 1&12)		
1	Knowledge	20

2	Procedure follows	30
3	Observation Skill	20
4	Conclusion/ Summary	10
5	Quality of Report	10
6	Punctuality	10
Total		**100**

Sample rubrics Performance Indicators for the PrOs

Demonstration type PrOs (PrOs Number 1 &12)					
Criteria	**%**	**10**	**9-8**	**7-6**	**5**
Knowledge	30%	Students give the correct answers 90% or more	Student give the correct answers between 70-89%	Student give the correct answers between 50-69%	Student give the correct answers less than 50%
Quality of Report	30%	Neat Handwriting, figure, and table. Complete labeling of figure and table.	Only formatting is not proper (Location of figures/tables, use of pencil and scale)	A few required elements (labeling/ notations) are missing	Several require elements content in paragraph, labels, figures, tables) are missing
Participation	25%	Excellent focused attention in the exercise	Moderately focused attention on exercise	Focused limited attention in the exercise	Participation is minimum
Punctuality	15%	Timely Submission	Submission late by one laboratory	Submission late by two laboratories	Submission late by more than two laboratories

Experimentation/performance type PrOs (PrOs number 2,3,4,5,6,7,8,9,10 & 11)					
Criteria	**%**	**10**	**9-8**	**7-6**	**5**
Knowledge	20%	Student give the correct answers 90% or more	Student give the correct answers between 70- 89%	Student give the correct answers between 50-69%	Student give the correct answers less than 50%

Procedure follows	30%	Student follow all the procedure with recaution in a logical order	Student follow all the procedure with some precaution in a logical order	Student follow all the procedure without precaution in a logical order	Student follow all the procedure without precaution in an illogical order
Observation Skill	20%	Excellent focused attention in the exercise	Moderately focused attention on exercise	Focused limited attention in the exercise	Participation is minimum
Conclusion/ Summary	10%	Student concept is mostly clear	Student concept is partly clear	Student concept is somewhat clear	Student concept is not clear
Quality of Report	10%	Neat Handwriting, igure, and table. Complete labeling of figure and table.	Only formatting is not proper (Location of figures/tables, use of pencil and scale)	A few required elements (labeling/ notations) are missing	Several require elements (content in paragraph, labels, figures, tables) are missing
Punctuality	10%	Timely Submission	Submission late by one laboratory	Submission late by two laboratories	Submission late by more than two laboratories

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

Sr.No.	Equipment Name with Broad Specifications	PrO. No.
1	CNC turning Machine (Tutor or productive) Min Diameter: 30 mm, Min Length: 120mm, ATC facility	1,2,6
2	CNC milling Machine (Tutor or productive) X axis travel:150mm Y axis travel: 150mm Z axis travel:100mm ATC facility	5,7,12

Sr.No.	Equipment Name with Broad Specifications	PrO. No.
3	CNC programming simulation software Latest version of any one from following softwares CNC simulator Pro Swansoft CNC	5,7,8
4	Software for CAD/CAM integration. Latest version of any one from following softwares Mastercam, NX Solid Edge.	4,10

7. AFFECTIVE DOMAIN OUTCOMES

The following sample Affective Domain Outcomes (ADOs) are embedded in many of the Above-mentioned COs and PrOs. More could be added to fulfill the development of this course competency.

a) Work as a leader/ team member.
b) Follow safety practices.
c) Follow ethical practices
d) Maintain tools and equipment
e) Practice environment-friendly methods and processes. (Environment-related)

The ADOs are best developed through laboratory/field-based exercises. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should
gradually increase as planned below:
I. 'Valuing Level' in 1st year.
II. 'Organization Level' in 2nd year.
III. 'Characterization Level' in 3rd year.

8. UNDERPINNING THEORY:

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
Unit – I Fundamentals of process planning	1a. Analyze Operation Sequence. 1b. Develop Route Sheet	1.1 Process planning 1.2 Structure of process plan 1.3 Factors influencing process plan 1.4 Sequence of operation of process plan
Unit – II. CNC systems	2a. Distinguish between CAM, NC, CNC, and DNC 2b. Determine Selection Criteria for CNC Machines	2.1 CAM, NC,CNC and DNC 2.2 Selection criteria for CNC machines. 2.3 Adoptive Control
UNIT- III Constructional Features of CNC machines	3a. Illustrate the Working Principle of CNC Systems:.	3.1 Classifications of CNC Machine 3.2 Modes of

	3b. Explore Modes of Operations in CNC Machines:. 3c. Examine Different Toolings in CNC Systems:.	operation of CNC 3.3 Working of: Machine Structure, Slideways, Spindle drive, Axis drive, Recirculating ball screw Feedback devices (transducers, encoders), Automatic tool changer (ATC), Automatic pallet changer (APC). 3.4 CNC axis and motion nomenclature 3.5 CNC toolings – tool pre setting, qualified tool, tool holders and inserts
Unit – IV CNC Part Programming	4a. Recognize Axes in CNC Turning and Machining Centers:. 4b. Justify the Significance of Machine and Part Positions. 4c. Develop Part Programs for Turning and Milling: 4d. Highlight the Importance of Advanced Commands: 4e. Interface Software for Automated Part Programming:	4.1 Axes Identification in CNC turning and Machining centers 4.2 Machine zero, home position, work piece zero, programme zero. 4.3 CNC part programming: Programming format and Structure of part programme. 4.4 ISO G and M codes for turning and milling-meaning and applications of important codes. 4.5 Compensations: Tool length compensation, Pitch error compensation, Tool radius compensation. 4.6 Simple part programming for turning using ISO format having straight turning, taper turning (linear interpolation) and convex/concave turning (circular interpolation). 4.7 Simple part programming for milling using ISO format. 4.8 Importance, types, applications and format for: Canned cycles, Macro, Do loops, Subroutine, Mirror image. 4.9 CNC turning and milling part programming using canned cycles, Do loops and Subroutine. 4.10 CAD CAM integration: Concept Steps involved in CAD/CAM integration, CAM software.

Unit – V Maintenance of CNC Machine	5a. Acquaintance with CNC Systems Maintenance Practices:. 5b. Development and Management of Daily Checklist. 5c. Troubleshooting Mechanical and Electronic Issues:	5.1 Types of machine tools maintenance 5.2 Systems and Sub systems of CNC machines 5.3 CNC Maintenance practice: Tools required, Daily checklist, Problems related to mechanical systems, Backlash, Causes and precautions of electronics system

9. SUGGESTED SPECIFICATION TABLE FOR QUESTIONPAPER DESIGN:

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Fundamentals of Process Planning	4	-	3	4	7
II	Introduction to CNC systems	6	3	4	3	10
III	Constructional Features of CNC machines.	10	4	6	6	16
IV	CNC part programming.	18	5	10	15	30
V	Maintenance in CNC machines	4	2	2	3	7
	Total	42	14	25	31	70

Legends: R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)

Note: This specification table gives general guidelines to assist students in their learning, and to the teachers, for question paper design and teaching methodology to formulate test items/questions to assess the attainment of the UOs. The actual distribution of marks at different taxonomy levels (of R, U, and A) in the question paper may slightly vary from the above table

10. SUGGESTED STUDENT ACTIVITIES

S NO	Activity
1	Download simulation software for free and validate part programs through simulation.
2	For any component generate part programs using Computer-Aided Manufacturing (CAM) software.
3	Analyze and interpret tool designations.
4	Visit industries equipped with CNC machines or explore websites of renowned CNC suppliers. Compile a specification list and gain insights into operation and maintenance practices.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

Sr. No.	Unit	Unit Name	Strategies
1	I	Fundamentals of Process Planning	Study of actual routesheets available, Industrial visits
2	II	Introduction to CNC systems	Videos, Presentations,

			Industrial Visits, expert lectures
3	III	Constructional Features of CNC machines	Videos, Presentations, Industrial Visits, expert lectures
4	IV	CNC Programming	Simulation softwares
5	V	Maintenance in CNC machines	Demonstration

12. SUGGESTED PROJECT LIST

Only one micro project will be given by the teacher to the students. The micro project should cover at least 2 COs which are integration of PrOs, UOs, and ADOs. Each student will have to submit a report related to their assigned micro project at the end of the semester. The following is the suggested micro-projects list which should be matched with the competency and Cos.

- CNC part programming of any simple object with the use of CNC codes.
- Implement features such as MACRO, CANNED CYCLE, and SUBROUTINE using ISO format.
- Visit any Manufacturing industry and find out production parts and prepare detailed part and Assembly drawings.
- Visit the Automation industry and prepare specifications for CNC turning, CNC Milling, etc.
- Prepare Axis Designation model of CNC Turning, CNC Milling, etc.
- Prepare a report on different accessories used like Ball screws, Guideways, Slideways, ATC, APC, and Sensors used.
- Prepare a report on tool offset.
- Prepare a report tool compensation method.
- Prepare a report on different techniques used for work holding in different CNC Machines.
- Prepare a model on work zero, machine zero axis.
- Solve examples of identifying machining costs with the use of different CNC machines.
- Prepare a report on different types of CNC controllers available in the market.

13. SUGGESTED LEARNING RESOURCES

Sr No	Title of Book	Author	publication
1	CNC Machines	Pabla B.S., Adithan M	New Age International, New Delhi,2014(reprint)
2	CAD/CAM: computer-aided design and manufacturing	Groover Mikell P, Zimmered W Emory	Prentice Hall 2011
3	Computer Aided Manufacturing	Rao P N, Tiwari N K, Kundra T	Tata McGraw Hill 2014
4	CAD/CAM/CIM	P. Radhakrishnan, S.	New Age

		Subramaniyan & V. Raju	International Pvt. Ltd., New Delhi, 3rd Edition
5	CNC Fundamentals And Programming	P. M. Agrawal, Dr. V. J. Patel	Charotar Publication

14. SOFTWARE/LEARNING WEBSITES

1. https://academy.titansofcnc.com/
2. https://www.cnccookbook.com/online-cnc-training-courses-guides-help/
3. https://www.siemens.com/global/en/industries/machinebuilding/machine-tools/cnc4you/education-training.html
4. https://www.mastercam.com/news/blog/learn-how-to-use-cnc-software/
5. https://www.siemens.com/global/en/industries/machinebuilding/machine-tools/cnc4you/education-training/cnc-courses.html
6. https://www.autodesk.in/solutions/cnc-programming
7. https://archive.nptel.ac.in/courses/112/105/112105211/
8. https://nptel.ac.in/courses/112102103
9. https://www.youtube.com/watch?v=IPnr1cdaT1s&list=PLT1NMjA2P81Frwoo5PLbL9IbhjMEaO8kK&pp=iAQB
10. http://vlabs.iitkgp.ernet.in/vlabs/rtvlab1/cncbase%20software.html
11. https://fab-coep.vlabs.ac.in/exp/3d-machining/
12. http://vlabs.iitkgp.ac.in/psac/newlabs2020/vlabiitkgpAM/exp2/index.html

15. PO-COMPETENCY-CO MAPPING:

Semester VI	**CNC Machines (Course Code:4362002)**						
	POs						
Competency & Course Outcomes	**PO 1** **Basic & Discipline specific knowledge**	**PO 2** **Problem Analysis**	**PO 3** **Design/ development of solutions**	**PO 4** **Engineering Tools, Experimentation &Testing**	**PO 5** **Engineering practices for society, sustainability & environment**	**PO 6** **Project Management**	**PO 7** **Life-long learning**
Course Outcomes CO1 Recognize various axes, machine zero, home position, systems, and controls of CNC machines	3	3	1	1	1	-	1
CO2 Choose, install, and	1	1	-	3	3	-	2

configure cutting tools and tool holders on CNC machines.							
CO3 Develop part programs using the ISO format for simple components, incorporating MACRO, CANNED CYCLE, and SUBROUTINE as needed.	2	3	2	1	2	-	1
CO4 Utilize software applications for automated part programming	1	-	2	1	1	2	1
CO5 Implement maintenance procedures for CNC machines	1	-	-	3	3	1	-

*Legend: '**3**' for high, '**2**' for medium, '**1**' for low and '**-**' for no correlation of each CO with PO.*

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons				
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