GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

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

Course Title: Computer Aided Manufacturing
(Course Code: 4351807)

Diploma programmer in which this course is offered	Semester in which offered
Marine Engineering	5th Semester

1. RATIONALE

The use of conventional machines is decreasing day by day. Evolution of information technology, variety of manufacturing concepts with zero lead time demand and quality consciousness has supported fast adaption of Computer Aided Manufacturing. CNC machines (computerized numerical control machines) are the main component in Computer Aided Manufacturing Systems. Efficient use of CNC machines requires excellent knowledge of programming and use of CNC tooling. In this course an attempt has been made to focus exclusively on constructional features of CNC machines, their programming and tooling, so that students may learn to use the CNC machines efficiently for manufacturing desired products. CAM is normally not only limited to machine tools but in real life its use has widened in almost all areas of manufacturing, processes and support activities.

2. COMPETENCY

The course content should be taught and implemented with the aim to develop requiredskills in the students so that they are able to acquire following competencies.

- Select required operating parameters, appropriate tools, tool holders, accessories and consumables for manufacturing a given job on CNC.
- Manufacture simple jobs using CNC part programming.

3. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills associated with the identified competency are to be developed in the student for the achievement of the following COs:

CO-1	Justify the need of CNC machines based on situations.
CO-2	Select, Mount and set Cutting tools and tool holders for CNC machines.
CO-3	Develop CNC Part Programmes for simple machine components as per ISO format.
C0-4	Develop CNC Part Programmes for complex jobs using MACRO, CANNED CYCLE and SUBROUTINE considering compensations.

CO-5	Adapt recent trends of Computer Aided Manufacturing for better productivity.

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	30*	70	25	25	150

(*): Out of 30 marks under the theory CA, 10 marks are for assessment of the micro-project to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessing the attainment of the cognitive domain UOs required for the attainment of the COs.

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

5. SUGGESTED PRACTICAL EXERCISES

Following practical outcomes (PrOs) are the sub-components of the Course Outcomes (Cos). Some of the **PrOs** marked **'*'** are compulsory, as they are crucial for that particular CO at the 'Precision Level' of Dave's Taxonomy related to 'Psychomotor Domain'.

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	**Demonstrate constructional features of CNC:** a. Demonstrate CNC machines and its operations. b. Identify major parts of CNC and draw sketch. c. Write specification of CNC taken for demonstration. d. Sketch important tool holders. e. Tabulate sensors / feedback devices with type, specification and purposes used on CNC taken for demonstration. f. Sketch display console. Also sketch symbols used on display console with meaning of each. State interfacing standards used.	II	06
2	**CNC turning part programming:** Teacher will assign part drawings. Minimum five drawings having following details are to be assigned. This include parts- (i) Simple turning with steps, (ii) Turning with tapers, (iii) Turning with circular (concave / convex shape) interpolation, (iv) Turning using canned cycle - with threading or drilling or other and (v)Turning with use of subroutine or macro or do-loop. Students would: a. Sketch each part with dimensions. b. Prepare CNC part programme using G and M codes with ISO format.	IV	10

	c. Show various zeros and tool path on part sketch with color codes and dimensions. d. Simulate the prepared part programmes using available simulation softwares. Prepare the parts on CNC.		
3	**CNC machining centre part programming:** Teacher will assign part drawings. Minimum three drawings having following details are to be assigned. This include parts- (i) Simple contour milling (ii) Contour milling with (convex / concave) circular interpolation and (iii) contour milling with drilling / tapping. Students would: a. Sketch each part with dimensions. b. Prepare CNC part programme using G and M codes with ISO format. c. Show various zeros and tool path on part sketch withcolor codes and dimensions. d. Simulate the prepared part programmes using available simulation softwares. Prepare the parts on CNC.	IV	08
4	**Demonstration of CAD/CAM integration:** a. Demonstrate CAD / CAM integration. List interfacing standards.	III	02
5	**Industrial visit:** Visit nearby industry having CNC machines. List and state important features of them with detail specifications and name of manufacturers.	ALL	02
Total			28

Note

*i. More **Practical Exercises** can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match the COs. The above table is only a suggestive list*

The following are some **sample** 'Process' and 'Product' related skills (more may be added/deleted depending on the course) that occur in the above listed **Practical Exercises** of this course required which are embedded in the COs and ultimately the competency.

6. SPECIAL INSTRUCTIONAL STRATEGIES (If Any)

Sr. No.	Unit	Strategies
1	I	Visit nearby industry having CNC machines. List and state important features of them.
2	II	Prepare specifications of various types of CNC machines with images and names of manufacturers.
3	III	Download images and videos of CNC machines and its parts. Prepare one DVD in a batch and submit to batch teacher.

4	IV	Download free simulation softwares available on website and practice for part programming.

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/a 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 the 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

The major underpinning theory is given below based on the higher level UOs of *Revised Bloom's taxonomy* that are formulated for development of the COs and competency. If required, more such UOs could be included by the course teacher to focus on attainment of COs and competency.

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
Unit – I. Fundamentals of CAM	1a.Differentiate between NC, CNC and DNC. 1b.Identify Parameters Governing for Selection of CNC machines.	1.1 CAM - concept and definition. 1.2 NC (Numerical Control), CNC (Computerized Numerical Control) and DNC (Direct Numerical Control) -concept, features and differences. 1.3 Advantages and limitations of CNC. 1.4 Selection criteria for CNC machines.
Unit- II Constructional features of CNC machines.	2a.Classify CNC machines. 2b.Identify role of main elements of CNC machines. 2c.Identify CNC axes. 2d.Preset tool on CNC machines. 2e.Use qualified tools and tool holders on CNC machines.	2.1 CNC machines: Types, classification, working and constructional features. 2.2 Spindle drives and axes drives on CNCmachines. 2.3 Machine Structure- Requirements and reasons. Elements of CNC machines Types, Sketch, Working and Importance of: i. Slide ways. ii. Re-circulating ball screw. iii. Feedback devices (transducers, encoders) iv. Automatic tool changer (ATC). v. Automatic pallet changer (APC). 2.4 CNC axes and motion nomenclature. CNC tooling : i. Tool presetting concept ii. Qualified tools definition need and advantages. iii. Tool holders – types and applications.
Unit – III CNC Turning& Machining Centers.	3a.List features of specified CNC turning and machining centre. 3b.Identify various	3.1 CNC turning centres: i. Types. ii. Features. iii. Axes nomenclature. iv. Specification. v. Work holding devices -

	work holding and tool holding devices.	types, working and applications. vi. Tool holding and changing devices - types, working and applications. 3.2 CNC machining centres: i. Types. ii. Features. iii. Axes nomenclature. iv. Specification. v. Work holding devices-types,working and applications. vi. Tool holding and changing device types, working and applications.
Unit – IV **CNC Part Programming.**	4a. Interpret ISO format of CNC part programming with used codes. 4b. Prepare part programme byusing applicablecodes like G& Metc. 4c.Apply advanced CNC part programming features like canned cycle, do loop, subroutine etc. 4d.Describe Procedure for Setting various compensations on CNC. 4e. Prepare part programme considering Various compensations.	4.1 Definition and importance of various positions like machine zero, home position, work piece zero and programme zero. 4.2 CNC part programming: programming format and structure of part programme. 4.3 ISO G and M codes for turning and milling-meaning and applications of important codes. 4.4 Simple part programming for turning using ISO format having straight turning, taper turning (linear interpolation) and convex/concave turning (circular interpolation). 4.5 Simple part programming for milling usingISO format. 4.6 Importance, types, applications and formatfor: i. Canned cycles. ii. Macro. iii. Do loops. iv. Subroutine. 4.7 CNC turning and milling part programming using canned cycles, Do loops and Subroutine. 4.8 Need and importance of various compensations:

		i. Tool length compensation. ii. Pitch error compensation. iii. Tool radius compensation. iv. Tool offset. 4.9 Simple part programming using variouscompensations.
Unit – V **Recent trends in CAM.**	5a.Select suitable standard for CAD/CAM interfacing. 5b.List source of variability for adaptive control. 5c.Interpret different FMS layouts. 5d. Correlate areas of CIM. 5e. Identify typesand elements of robots. 5f. Describe concept of Rapid prototyping.	5.1Interfacing standards for CAD/CAM - Types and applications 5.2 Adaptive control- definition, meaning, block diagram, sources of variability and applications. 5.3 Flexible Manufacturing System (FMS) - concept, evaluation, main elements and their functions, layout and its importance, applications. 5.4 Computer Integrated Manufacturing (CIM) - Concept, definition, areas covered,benefits. 5.5 Robotics- definition, terminology, classification and types, elements and applications. 5.6 Rapid prototyping - Concept and application

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Fundamentals of Computer AidedManufacturing	4	4	6	0	10
II	Constructional Features of CNCmachines	5	6	4	4	14
III	CNC Turning & Machining Centers.	4	2	6	2	10
IV	CNC part programming.	10	4	6	14	24
V	Recent trends in CAM.	5	4	8	0	12
Total		**28**	**20**	**30**	**20**	**70**

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

Notes:

1. This specification table shall be treated as a general guideline for students and Teachers. The actual distribution of marks in the question paper may slightly vary from above Table.
2. If mid semester exam is part of continuous evaluation, unit numbers I, II, III and unit IV are to be considered.
3. Ask the questions from each topic as per marks weightage. Numerical questions are to be asked only if it is specified. Optional questions must be asked from the same topic.

10. SUGGESTED STUDENT ACTIVITIES

Perform the tasks mentioned in above Practical/Exercise.

NOTE: Students must develop CNC part Program of marine components and must get assessed by the concerned faculty at the completion of each component. Students will have to develop CNC part Program of any of those 10 marine components which will be counted in internal marks .
Students must be able to draw any one of those 10 marine components by him/ her.

11. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-projects are group-based (group of 3 to 5). However, **in the fifth and sixth semesters**, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The duration of the micro project should be about **14-16** ***(fourteen to sixteen) student engagement hours*** during the course. The students ought to submit micro-project by the end of the semester to develop the industry-oriented COs.

A suggestive list of micro-projects is given here. This has to match the competency and the COs. Similar micro-projects could be added by the concerned course teacher:
Effective use of following:

a) CNC Machine
b) CNC Part Program
c) Robotics
d) Flexible Manufacturing System
e) Computer Integrated Manufacturing

12. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Book	Author	Publication with place, year and ISBN
1	CAD/CAM: computer aideddesign and manufacturing.	Groover Mikell P, Zimmered W Emory	Prentice Hall 2014 ISBN:978-0139272399
2	Computer Aided Design and Manufacturing	Tien-Chien Chang, Richard A Wysk and Hsu-Pin Wang	Prentice Hall International Series on Industrial and System Engineering-2005 ISBN:- 978-0131429192
3	CAD/CAM	Sareen Kuldeep and Chandandeep Grewal	S.Chand-2012, ISBN:- 978-8121928748
4	CNC Programming Handbook: A Comprehensive Guide to Practical CNC Programming	Peter Smid	Industrial Press, Inc.,US-2007 ISBN:978-0831133474

13. LEARNING WEBSITES

a. https://ocw.mit.edu/courses/mechanical-engineering/2-830j-manufacturing-systems-and-processes-fall-2003/

b. https://www.cnccookbook.com/

c. https://www.autodesk.com/solutions/cam/learning-center

d. https://www.toolingu.com/

e. You tube Videos: https://www.youtube.com/user/saunixcomp

f. You tube Videos: https://www.youtube.com/@AmitPatel-uy2bo

14. PO-COMPETENCY-CO MAPPING

Semester V	COMPUTER AIDED MANUFACTURING (Course Code: 4351807)						
	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
Competency	**Prepare production drawings using the computer and relevant software and following standards codes and norms**						
Course Outcomes							
CO-1) Justify the need of CNC machines based on situations.	2	0	1	1	0	0	1
CO-2) Select, Mount and set Cutting tools and tool holders for CNC machines.	2	0	1	3	1	1	1
CO-3) Develop CNC Part Programmes for simple machine components as per ISO format.	2	2	3	3	2	1	1
CO-4) Develop CNC Part Programmes for complex jobs using MACRO, CANNED CYCLE and SUBROUTINE considering compensations. .	2	2	3	3	2	1	1
CO 5) Adapt recent trends of Computer Aided Manufacturing for better productivity.	1	1	1	1	1	1	1

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

15. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

S. No.	Name and Designation	Institute	Contact No.	Email
1.	Dr.S.H.Sundarani HOD Mechanical Engg	Government Polytechnic, Ahmedabad	9227200147	gpasiraj@gmail.com
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17. BOS Resource Persons

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3.	Dr. Atul S.Shah (BOS Member & Principal)	B. V. Patel Institute of Technology, Bardoli	7567421337	Asshah97@yahoo.in