GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

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

Semester-VI

Course Title: Computer-Aided Design / Computer-Aided Manufacturing

(Course Code: 4361902)

Diploma programmer in which this course is offered	Semester in which offered
Mechanical Engineering	6Th semester

1. RATIONALE

Computers have become inevitable in today's era and find their application in various stages of product development. The course is intended to provide exposure to modeling techniques assembly in parts and CNC job preparation and their CNC program. It also includes topics on feature-based CAD modeling. This course intends to introduce students to computer use in the phases of product design viz. conceptualization, and modeling. A topic on geometric modeling, and graphical representation. In this context, it is of utmost importance to prepare, read, and interpret these drawings correctly to produce components and assemblies accurately and precisely. The industrial practices of modeling and designing are also important for the students to make them aware of modeling and designing practices, symbols, codes, norms, and standards generally used in industries. The manufacturing field has witnessed the recent development happening in CAD-CAM areas. CNC machines play a big role in the manufacturing field. An attempt has been made to focus on CNC machine tools, related programming, and their advanced features.

2. COMPETENCY

The course content should be taught and implemented to develop the different types of skills so that students can acquire the following competencies:

- **Development of 3D modeling, machine drawings/production drawings/assembly drawings, and their solid models using different types of 3D commands**. **Understanding the reference planes and axes, different constraints for preparation of 3d solid models, and assembly.**
- **Selection of required operating parameters, appropriate tools, tool holders, accessories, and consumables for manufacturing a given job on CNC.**
- **Manufacture methods of 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. At the end of the course, the student will be able to:

CO-1	To understand the basics of CAD solid and surface modeling methods.
CO-2	To create 3D models and assembly of 3D parts in CAD software.
CO-3	To demonstrate the working of a CNC machine.
CO-4	Develop the part program and simulation of the part program in a CNC Machine.
CO-5	To demonstrate interface software between CAD and CAM for auto part programming.

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	
03	00	02	04	30	70	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:

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

Sr No.	Practical Outcomes (PrOs)	Concerned Unit No.	Approx Hrs. Required
01	**3D Solid Modeling-I** Demonstrate various 3D Solid commands used in 3D creation, 3D Modify, and Pure primitives using datum planes/preference panes and datum axis/reference axis different types of constraints.	01 & 02	04
02	**3D Solid Modeling-II:** • Prepare a 3D solid model using any one parametric software (Creo, Unigraphics, CATIA, Solid Edge, Inventor, Solid Works, etc). • Assembly of the different modeling parts • Preparation of drawing sheet from 3D model/3D assembly.	03	06
03	**Demonstrate constructional features of CNC:** a. Demonstrate the CNC machines and their operations. b. Identify the major parts of CNC and draw a sketch. c. Write the specifications of CNC taken for demonstration.	04 & 05	04

	d. Importance of tool holders, and types of CNC tools. e. Tabulate sensors/feedback devices with type, specification, and purposes used on CNC taken for demonstration.		
04	**CNC turning part programming:** The teacher will assign part drawings. A minimum of five drawings having the following details are to be assigned. This includes 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 canned cycle and subroutine. Students should do the following activities: a. Sketch of each part with dimensions. b. Prepare the CNC part program using G and M codes with ISO format. c. Show various zeros and tool paths on the part sketch with color codes and dimensions. d. Simulate the prepared part programs using available simulation software. e. Prepare the parts on CNC Machines.	06	04
05	**CNC machining center part programming:** The teacher will assign part drawings. A minimum of three drawings having the following details are to be assigned. This includes parts- (i) Simple contour milling (ii) Contour milling with (convex/concave) circular interpolation and (iii) contour milling with drilling/tapping. Students should do the following activities: a. Sketch of each part with dimensions. b. Preparing the CNC part program using G and M codes with ISO format. c. Show various zeros and tool paths on the part sketch with color codes and dimensions. d. Simulate the prepared part programs using available simulation software. e. Prepare the parts on CNC.	06	04
06	**Demonstrate the automated CNC program in Mater CAM /Inventor-CAM/Solid Works-**	06	06

	CAM/ Unigraphics or any CAD software with the Application of the CAM feature. • Selection of reference axis selection of models for automated CNC programs for the relevant type of CNC machines. • Simulation of automated CNC program with tool and tool holder selection, Tool compensation methods tool offset. • Demonstrate CAD / CAM integration in the above-mentioned CAM Software. • Demonstrate on CNC Lathe, or VMC for work holding, Tool compensation methods, and tool offset. • (Optional) Run the automated CNC program prepared from above mentioned CAD-CAM software in the CNC machine or CNC trainer.		
07	**Industrial Visit & and expert lecture** • Visit nearby industries having CNC machines. List and state important features of them with detailed specifications and names of manufacturers. • Arrange a lecture from an expert related to any CAD-CAM software, and recent trends in CAD-CAM.	ALL	-
		TOTAL HRS	28

Note:

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

Sr. No.	Sample Performance Indicators for the PrOs	Weightage in %
1	Knowledge	20
2	Quality of Report/Sketch/Drawings/Jobs.	30
3	Participation	30
4	Punctuality	20
	Total	**100**

Sample rubrics Performance Indicators for the PrOs.

Criteria				
Knowledge	Students give the correct answers 90% or more	Students give the correct answers between 70-89%	Students give the correct answers between 50-69%	Students give the correct answers less than 50%
Quality of Report/Sketch/Drawing/Jobs.	1. Individual part is duplicated with 100% accuracy. 2. Accurate Assembly of parts. 3. Accurate and Neat Sketch. 4. Accurate Part Program. 5. Accurate Job.	1. Individual part is duplicated with up to 70 to 80% accuracy. 2. Improper Assembly of parts. 3. One or two mistakes in a sketch. 4. One or two mistakes in Part Program. 5. One or two mistakes in the job.	1. Individual part is duplicated with up to 50 to 60% accuracy. 2. Incomplete Assembly of parts. 3. More than 03 mistakes in the sketch. 4. More than 03 mistakes in Part Program. 5. More than 03 mistakes in the job.	1. Individual part is duplicated less than 50%. 2. Can't assemble parts. 3. In-Complete sketch. 4. Incomplete Part Program. 5. Incomplete Job.
Participation	Used time well in the lab and focused attention in the exercise	Used time mostly in lab focused attention on exercise	Used time moderate in the lab focused attention in the exercise	Participation is minimum
Punctuality	Submission on time	Submission late by 1 laboratory	Submission late by 2 laboratories	Submission late by more than 2 laboratories

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

Sr.No.	Equipment Name with Broad Specifications	PrO. No.
01	**Cad Workstation with Software:** Suggested Workstation configuration: • Intel i3 (10th generation and above)/Intel i5(8th generation and above)/intel i7 (6th generation)/Ryzen 5 (5th generation and above)/ Ryzen 7 (4th generation and above). • 8GB or above DDR3/DDR4/DDR5 RAM • 500 GB SSD or NVME M.2 SSD • Internet. • Integrated or external UHD graphic card Software for CAD-CAM (Any One): • AutoCAD (Free educational version for educator/student is available*) • Autodesk Inventor Professional with CAM feature (Free educational version for educator/student is available*). • Unigraphics with CAM feature. • SolidWorks with CAM feature. • Mastercam.	01 & 02 & 06
02	CNC Lathe machine or CNC trainer and different types of CNC tools.	03 & 04
03	VMC Machine or VMC trainer and different types of CNC tools.	03 & 05
04	Vernier, Micrometer, Surface plate.	06

**Account in Autodesk website, documents, authority letter, transcript, I-card required*

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:

Based on the higher-level UOs of Revised Bloom's taxonomy formulated for developing COs and competency, the primary underpinning theory is given below. If required, more such UOs could be included by the course teacher to focus on attaining COs and competency.

Unit	Unit Outcomes (UOs)	Topics & Sub-Topics
Unit -1 Introduction of CAD.	1a. Basic of CAD & its application.	1.1 CAD Definition, concept, and need. 1.2 CAD Process. 1.3 Functional Areas of CAD. 1.4 Applications of CAD. 1.5 Input / Output devices.
Unit-2 Geometric Modeling & 3D Modeling.	2a. Types of modeling.	2.1 Difference between 2D & 3D Models. 2.2 Wireframe, Surface & Solid Modeling. 2.3 Solid modeling methods like Constructive Solid Geometry, Pure primitives, and boundary Representation.
	2b. Feature base Modeling.	2.4 Feature-Based Modeling Concepts. 2.5 Parametric & non-Parametric Modeling concepts & its differences.
	2c. Introduction of 3D Commands.	2.6 AutoCAD 3D commands related to Pure primitives (BOX, CYLINDER, CONE, SPHERE, TORUS, PYRAMID, and WEDGE.) 2.7 3D Draw Commands (Extrude, Revolve, Sweep, Sweep blend (Loft), etc.) 2.8 Boolean Operations. 2.9 3D Modify & Editing Commands. 2.10 3D Viewing. 2.11 Importance of surface modeling. 2.12 AutoCAD surface modeling commands (EDGESURF, PLANESURF, RULESURF, REVSURF, TABSURF, 3DMESH, etc.).

Unit-3 3D Parametric Modeling and Assembly in CAD Software.	3a. Make a Solid model and assembly detail drawing using parametric software.	3.1 Introduction to parametric modeling software (Any one CATIA, Creo, Solid Works, Unigraphics, AutoCAD, Inventor/Solid Works, etc) 3.2 Understanding of 3D datum panes/ working planes / Reference planes, Axis and Constraints. 3.3 3D modeling using different 3D solid commands. 3.4 Assembly Modeling and creation of assembly and details drawing sheet for those parts. 3.5 Bill of Materials (BOM)
Unit 4 Introduction of CNC and CNC Machine Tools.	4a. Introduction of NC, CNC, and DNC. 4b. Introduction of CNC Machine tools.	4.1 CAM Concepts & definitions. 4.2 NC, CNC, & DNC concept, Feature & difference. 4.3 Advantages & Limitations & Application of CNC. 4.4 Selection Criteria of CNC Machines. 4.5 Types of CNC Tools and Tool Holders. 4.6 CNC machines: Types, classification, working and constructional features.
Unit 5 CNC machine components.	5a. Identify the role of the main components of CNC machines. 5b. Identify CNC axes.	5.1 CNC Machine building, structural details, CNC block diagram. 5.2 Spindle drives and axes drives on CNC machines. 5.3 Components of CNC machines - Types, sketch, working and importance of: • Different types of drives • Slideways. • Re-circulating ball screw. • Feedback devices (transducers, encoders). • Automatic tool changer (ATC). Automatic pallet changer (APC).

Unit 6 CNC part programming and recent trends.	6a. Interpret the ISO format of CNC part programming with used codes. 6b. Prepare part program by using applicable codes like G & M etc. 6c. Apply advanced CNC part programming features like a canned cycle, subroutine, etc. 6d. Describe the procedure for Setting various compensations on CNC. 6e.Recent trends in CNC Part programming.	6.1 Definition and importance of various positions like machine zero, home position, workpiece zero, and program zero. 6.2 CNC part programming: programming format and structure of the part program. 6.3 ISO G and M codes for turning and milling-meaning and applications of important codes. 6.4 Simple part programming for turning using ISO format having straight turning, taper turning (linear interpolation), and convex/concave turning (circular interpolation). 6.5 Simple part programming for milling using ISO format. 6.6 Importance, types, applications, and format for: • Canned cycles. • Subroutine. 6.7 CNC turning and milling part programming using canned cycles, and Subroutine. 6.8 Need and importance of various compensations: • Tool length compensation. • Pitch error compensation. • Tool radius compensation. • Tool offset. 6.9 Introduction of CAM software and application of automated part programming method & its feature scope.

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN:

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
01	Introduction of CAD.	04	03	01	00	04
02	Geometric Modeling & 3D Modeling.	06	02	06	04	12
03	3D Parametric Modeling & CAD Database.	08	02	04	06	12
04	Introduction Of CNC Machine Tools.	04	04	06	00	10
05	Hardware & Drives & Control system.	10	06	04	02	12
06	CNC part programming and recent trends.	10	04	06	10	20
Total		42	21	27	22	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

Sr. No.	Activity
01	Visit the design section of different industries and observe various hardware and Software, procedures, and standards they are following for designing a product.
02	Bring Actual mechanical assembly from industry/real life/scrap shop/garage/etc. Dismantle the same, measure dimensions, and prepare 3D parts.
03	Prepare a 3D model of a part from an orthographic drawing sheet and an isometric drawing from any machine design book and make assembly models of those different parts.
04	Prepare a 3D model using sheet metal features of CAD software (Inventor, Creo, Unigraphics, Solid Works, Solid Edge, etc.).
05	Give the information on free simulation software available on the website, download from its website, information about the installation of that software, and make a practice of part Programming.
06	Draw a simple sketch of a job and write the CNC part program using different CNC Codes according to ISO format.
07	Make simulation and automated CNC programs of the part created from student activity No 3 and 4 using tool setting, tool compensates workpiece zero, and machine zero.

	references in any CAD-CAM software (Master CAM, Inventor-CAM, Creo, Solid Works-CAM, etc).
08	Prepare a report on different errors generated during job making in different CNC Machines and identify & find solutions.
09	Prepare a report on different types of CNC controllers available in the market.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

Sr. No	Unit	Strategies
01	I & II	a. Explain various configurations for CAD workstations and different peripherals regarding the processor, RAM, graphics, and hard drive. b. Demonstrate various Input/output devices and their connections and how to use them. c. Demonstrate the procedure of installing the CAD software on a computer system.
02	III	Bring actual industrial production drawings/machine drawings/assembly drawings and distribute them among a group of students for self-study and interpretation. Ask students to practice these drawings using CAD software.
03	IV & V	Videos, Presentation, Demonstration.
04	VI	Simulation software, actual practice on CNC machines, Demonstration.
05	(Optional)	Create or demonstrate the creation of an account on the Autodesk website. If possible then download the education version of AutoCAD, the education version of Inventor Professional with CAM, and the education version of Fusion 360. All these software are available on mobile platforms so the applicant/students can save their work on their account and get access on mobile through the cloud. So, students can get awareness of recent trends in CAD sectors.

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.

- Any two Solid models of any components. Creation of an orthographic drawing sheet from those components with the dimensions.
- Only one Assembly of components. Creation of an orthographic drawing sheet from that assembly with the dimensions and part list.
- CNC part programming of any simple object with the use of CNC codes.
- Automated CNC program from 3D solid modeling part and CNC simulation in CAD-CAM software.

- 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
01	Creo 2.0 for designer and engine designers	Sham Tickoo	Dream tech press
02	Designing with Creo Parametric 2.0	Dr. Michel J Rider	SDC Publications
03	Unigraphics for designers & engineers	Sham Tickoo	Dream tech press
04	Autodesk Inventor Professional 2022 for Designers	Sham Tickoo	Dream tech press
05	CNC Machines	Pabla B.S., Adithan M.	New Age International, New Delhi,2014(reprint)
06	CAD/CAM: computer-aided design and manufacturing	Groover Mikell P, Zimmered W Emory	Prentice Hall 2011
07	Computer Aided Manufacturing	Rao P N, Tiwari N K, Kundra T	Tata McGraw Hill 2014
08	CAD/CAM/CIM	P. Radhakrishnan, S. Subramaniyan & V. Raju	New Age International Pvt. Ltd., New Delhi, 3rd Edition

14. SOFTWARE/LEARNING WEBSITES

1. Autodesk AutoCAD (Educational network or stand-alone licensed latest Version).
2. Autodesk Inventor Professional with CAM feature or Creo (Pro-Engineer) or Solid Edge (Educational network or stand-alone licensed latest Version).
3. Unigraphics NX with CAM features.
4. Master CAM

Learning websites

CAD:

1. https://www.autodesk.com/education/edu-software/autocad
2. https://www.autodesk.in/campaigns/autocad-tutorials
3. https://www.autodesk.com/education/support
4. http://www.autocadmark.com/

5. http://www.autocadtutorials.net/

CAM:

1. https://www.autodesk.in/products/inventor/trial-intake
2. https://www.autodesk.in/products?page=2
3. http://www.nptel.ac.in
4. http://www.youtube.com/watch?v=M3eX2PKM1RI
5. http://www.youtube.com/watch?v=hJFLcvtiNQI

15. PO-COMPETENCY-CO MAPPING:

Semester V	**(Course Code:4361902)**						
	POs						
Competency and Course Outcomes	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
	Basic and Discipline-specific knowledge	**Problem analysis**	**Design/ development of solutions**	**Engineering Tools, Experimentation, and Testing**	**Engineering Practices for society, sustainability, and environment**	**Project Management**	**Life-long learning**
CO-1 To understand the basics of CAD solid and surface modeling methods.	03	02	02	-	-	-	02
CO-2 To create 3D models and assembly of 3D parts in CAD software.	03	02	02	-	-	-	02
CO-3 To demonstrate the working of a CNC machine.	03	03	02	02	02		02
CO-4 Develop the part program and simulation of the part program in a CNC Machine.	03	03	02	02	02		02
CO-5 To demonstrate interface software between CAD and CAM for auto part programming.	03	02	01	02	02	-	02

*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

Sr. No.	Name and Designation	Institute	Contact No.	Email
01	N J Parmar, Lecturer	G P Porbandar	9275068215	niraj08me687@gmail.com
02	D V Moridhara, Lecturer	B AND B Institute of Technology VV Nagar-388120	6355998744	dvmoridhara@bbit.ac.in
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