

**GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)**

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

Semester-V

**Course Title: Computer Aided Design**

(Course Code: 4356503)

<b>Diploma program in which this course is offered</b>	<b>Semester in which offered</b>
Mechanical Engineering (CAD/CAM)	5 <sup>th</sup> Semester

### 1. RATIONALE

This CAD course is essential for mechanical engineers, especially those specializing in CAD/CAM, providing a comprehensive foundation in computer-aided design. Students will explore the history, concepts, and applications of CAD, understanding its critical role in modern engineering. The course covers key topics such as coordinate systems, line and curve generation algorithms, and geometric transformations, vital for precise and accurate design work. Knowledge of graphic standards and CAD/CAM data exchange formats ensures seamless integration and communication within design platforms. By learning about curve representation methods and various surface types, students can create detailed and complex models. The curriculum also includes solid model representation schemes and feature-based modeling, equipping students with advanced modeling techniques. Additionally, an introduction to Finite Element Analysis (FEA) prepares students to analyze and solve engineering problems effectively. This course ensures that students are proficient in modern design methodologies and tools, preparing them for successful careers in the engineering field.

### 2. COMPETENCY

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

- Master the fundamental concepts and applications of CAD, including the use of CAD systems, coordinate systems, line and curve generation algorithms, geometric transformations, and various modelling techniques.
- Proficiently utilize graphic standards, data exchange formats, and Finite Element Analysis (FEA) tools to create, analyse, and optimize detailed and complex engineering designs

### 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	Appreciate principles and tools for Computer Aided Design.
CO-2	Utilize graphic standards, data exchange formats, and geometric transformations for

	engineering models.
CO-3	Utilize parametric representations of curves and surfaces by enabling effective modeling in CAD applications.
CO-4	Compare various modeling techniques in CAD.
CO-5	Apply Finite Element Analysis (FEA) techniques for structural, thermal and fluid problems of mechanical components.

#### 4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P/2)	Examination Scheme				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	CA	ESE	CA	ESE	
2	0	2	3	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 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)	Unit No.	Approx. Hrs. Required
01	Preparatory Activity <ul style="list-style-type: none"> <li>Suggest CAD system configuration.</li> <li>List out various CAD software and compare their silent features.</li> </ul>	I	02
02	Program for Plotting Lines and Circles Using DDA and Bresenham's Algorithms in C-Graphics.	III	04
03	Prepare a simple model in CAD software using surface and solid model and compare its various properties.	IV	02
04	Introduction to Octave /MATLAB or any similar software for various matrix operations and data plot.	-	04
05	Solve 2D geometric transformation problems using Octave/MATLAB or any similar software and plot the resulting shapes.	II	04
06	Solve 1-D problems (mechanical element, fluid and thermal system) with the help of elimination approach and penalty approach using Octave/MATLAB or any similar software.	V	06
07	Introduction to Finite Element Analysis software.*	V	02
08	Design a simple mechanical element (e.g., shaft, lever) and create a 3D model of it. Validate the traditional design using FEA software and compare the results.*	V	04
<b>Total (Hours)</b>		-	<b>28</b>

**Note:**

- I. 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.

**Sample rubrics Indicators for the PrOs**

<b>Criteria</b>	<b>Excellent: 5</b>	<b>Very Good: 4</b>	<b>Good: 3</b>	<b>Fair: 2</b>
<b>Knowledge</b>	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%.
<b>Correctness</b>	Program produces correct answers or appropriate results for all inputs tested.	Program produces correct answers or appropriate results for most inputs	Program approaches correct answers or appropriate results for most inputs, but can contain miscalculations in some cases.	Program does not produce correct answers or appropriate results for most inputs.
<b>Participation</b>	Excellent focused attention in the exercise.	Moderately focused attention on exercise.	Focused limited attention in the exercise.	Participation is minimum.
<b>Punctuality</b>	Punctual in the lab and experiment is completed within the specific time.	Late in the lab but experiment is completed within the Specific time.	Late in the lab but experiment is not completed within the specific time.	Experiment is done in extra lab due to absence on assigned days.
<b>Timely submission</b>	Timely Submission.	Submission late by one laboratory.	Submission late by two laboratories.	Submission late by more than two laboratories.

**6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED**

This major equipment with broad specifications for the PrOs is a guide to procure them by the administrators to a user in uniformity of practice in all institutions across the state.

<b>Sr. No.</b>	<b>Equipment Name</b>	<b>PrO. No.</b>
1.	Computer system with latest configuration.	All
2.	Software tool: C Compiler / Visual Studio	1
3.	GNU Octave / MATLAB or similar software	2,3,4,5
4.	FEA software	6,7

**7. AFFECTIVE DOMAIN OUTCOMES**

The following **sample** Affective Domain Outcomes (ADOs) are embedded in many of the above

COs and PrOs. More can 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. Realize the importance of E-waste management. (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 1<sup>st</sup> year
- II. 'Organization Level' in 2<sup>nd</sup> year.
- III. 'Characterization Level' in 3<sup>rd</sup> 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) (4 to 6 UOs at different levels)	Topics and Sub-topics
Unit – I Introduction	1.a Explain the historical development and various applications of CAD. 1.b Identify the need, key features, benefits, and functional areas of CAD. 1.c Outline design steps and justify the implementation of CAD in projects. 1.d Compare various CAD software and their key features. 1.e Explain the model coordinate system in CAD	1.1 History, concept, definitions and applications of CAD 1.2 Need, salient features, benefits and functional areas of CAD 1.3 Design steps using CAD system and reasons for implementing same. 1.4 List of available CAD software and their features. 1.5 Concept of Coordinate Systems <ol style="list-style-type: none"> <li>i. Working Coordinate System</li> <li>ii. Model Coordinate System</li> <li>iii. Screen Coordinate System.</li> </ol>
Unit – II CAD Standards and Geometric Transformations	2.a Appreciate graphic standards, their need, types, features, system requirements, applications, and GUI concepts. 2.b Describe the need for data exchange, types of formats, IGES, and STEP in CAD/CAM. 2.c Apply 2D and 3D geometric transformations in CAD.	2.1 Graphic Standard : Need, Types, features, system requirements and applications ; GUI- concept meaning & features 2.2 CAD/CAM Data Exchange Formats: <ul style="list-style-type: none"> <li>• Need and method of Data exchange</li> <li>• Types of data exchange formats</li> <li>• IGES data representations and structure</li> <li>• STEP architecture and Implementation</li> </ul> 2.3 Geometric Transformations. <ol style="list-style-type: none"> <li>i. 2D geometric transformation: Translation, Scaling, Reflection,</li> </ol>

		<p>Rotation, Shearing, Homogeneous Coordinates, Composites transformation. Examples based on 2D transformation.</p> <p>ii. 3D geometric transformation: Translation, Rotation, Scaling, Reflection (Only Theory).</p>
Unit-III Lines, Curves and Surfaces	<p>3.a Implement DDA, Bresenham's line, and circle generation algorithms.</p> <p>3.b Explain parametric representation of curves, including lines, circles, ellipses, parabolas, and hyperbolas.</p> <p>3.c Describe parametric representation of surfaces such as plane, ruled, edge, revolution, Bezier, and B-spline.</p>	<p>3.1 Line and Curve generation algorithm:</p> <ol style="list-style-type: none"> <li>I. Line generation algorithm - DDA, Bresenham's algorithms (with examples)</li> <li>II. Circle generation algorithm - Bresenham's algorithms (No examples)</li> </ol> <p>3.2 Introduction to parametric representation of curves with its advantages and applications.</p> <p>3.3 Analytic Curves (Only Theory)</p> <ul style="list-style-type: none"> <li>• Line, circle, parabola, hyperbola, ellipse.</li> </ul> <p>3.4 Synthetic Curves its Properties, applications.(only Theory):</p> <ul style="list-style-type: none"> <li>• Concept of continuity</li> <li>• Cubic Spline, Bezier Curve, B-Splines.</li> </ul> <p>3.5 Introduction to parametric representation of various types of surfaces (only Theory):</p> <ol style="list-style-type: none"> <li>i. Analytical surface: Plane, ruled, edge, revolution, tabulated</li> <li>ii. Synthetic surface: Bezier, B-spline.</li> </ol>
Unit-IV Representation of solids	<p>4.a Explain the concept and relationship between geometry and topology.</p> <p>4.b Compare wireframe, surface, and solid models and describe solid model properties.</p> <p>4.c Describe solid model representation schemes</p> <p>4.d Apply feature-based modeling techniques in CAD.</p>	<p>4.1 Concept and relation between Geometry and Topology</p> <p>4.2 Comparison of wireframe, surface and solid models, Properties of solid model</p> <p>4.3 Representation schemes of solid models:</p> <ul style="list-style-type: none"> <li>• B-rep, CSG, Sweep representation, Primitive instancing, Cell Decomposition.</li> </ul> <p>4.4 Feature based modeling</p>

Unit-V Finite Element Analysis	5.a	Describe the basic procedure for solving problems using FEA.	5.1	Basic procedure for solving a problem using Finite Element Analysis.
	5.b	Explain shape functions, natural coordinates, and the derivation of the stiffness matrix in 1-D analysis.	5.2	1-D Analysis: <ul style="list-style-type: none"> <li>• Concept of Shape function and natural coordinates (Only Theory)</li> <li>• strain - displacement matrix</li> <li>• derivation of stiffness matrix using elimination approach and penalty approach with examples</li> <li>• properties of stiffness matrix</li> </ul>
	5.c	Understand the basics of 1-D thermal and fluid problems.	5.3	1-D thermal and fluid problems (Introductory level).
	5.d	Identify popular FEA packages, element types, boundary conditions, and basic steps for using FEA software.	5.4	Popular FEA packages, Types of elements, Boundary conditions, Basic steps to solve FEA using packages.

## 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
I	Introduction	04	6	6	-	12
II	CAD Standards and Geometric Transformations	06	6	3	7	16
III	Lines, Curves and Surfaces	08	6	4	7	17
IV	Representation of solids	04	6	4	-	10
V	Finite Element Analysis	06	4	4	7	15
<b>Total</b>		<b>28</b>	<b>28</b>	<b>21</b>	<b>21</b>	<b>70</b>

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

## 10. SUGGESTED STUDENT ACTIVITIES

Sr. No.	Activity.
1.	Research and present a timeline of key milestones in the development of CAD.
2.	Conduct a group discussion on the benefits of CAD in different industries such as automotive, aerospace, and architecture.
3.	Create a presentation highlighting specific functional areas where CAD is crucial, such as design, simulation, and manufacturing.
4.	Prepare case studies showcasing successful implementation of CAD in real-world design projects.
5.	Research and compile a list of popular CAD software, comparing their features, pricing, and industry applications.
6.	Implement DDA and Bresenham's algorithms in a programming environment to visualize and compare their efficiency in line generation.

7.	Create a poster or infographic detailing the importance of graphic standards in CAD, with examples of different types and their applications.
8.	Explore various interactive simulations or animations, illustrating 2D transformations such as translation, rotation, and scaling using CAD tools.
9.	Research and present case studies on the application of Bezier curves, B-splines, and other surface types in CAD modeling.
10.	Experiment with feature-based modeling to create parametric designs that can be easily modified and updated.
11.	Solve engineering problems using FEA software to analyze stress distribution
12.	Present findings from FEA simulations, discussing the implications of different element types and analysis methods.

### 11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies that the course teacher can use to accelerate the attainment of the various outcomes in this course.

Unit	Unit Title	Strategies
I	Introduction	<ol style="list-style-type: none"> <li>1) Provide a timeline of CAD development and its applications in various industries.</li> <li>2) Engage students in discussions about the importance and impact of CAD on modern engineering.</li> </ol>
II	CAD Standards and Geometric Transformations	<ol style="list-style-type: none"> <li>1) Analyze real-world examples to show the application of CAD standards and transformations.</li> <li>2) Use diagrams and animations to explain different types of geometric transformations.</li> </ol>
III	Lines, Curves and Surfaces	<ol style="list-style-type: none"> <li>1) Have students write and execute algorithms for line and curve generation.</li> <li>2) Provide exercises for creating and manipulating lines, curves, and surfaces in CAD software.</li> </ol>
IV	Representation of solids	<ol style="list-style-type: none"> <li>1) Assign projects where students create and compare wireframe, surface, and solid models.</li> <li>2) Show live demonstrations of solid modeling techniques and representation schemes.</li> </ol>
V	Finite Element Analysis	<ol style="list-style-type: none"> <li>1) Use FEA software to perform simulations and interpret the results.</li> <li>2) Invite industry professionals to discuss the application of FEA in real-world scenarios.</li> </ol>

### 12. SUGGESTED MICRO-PROJECTS

**Only one micro-project** is planned to be undertaken by a student that needs to be assigned at the beginning of the semester. 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 at least COs with in integration of PrOs, UOs, and ADOs. The duration of the micro project should be about **4-5 (four to five) student engagement hours** during the course. The students ought to submit a micro-project by the end of the semester to develop the industry-oriented COs.

A representative 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 or using suggested student activity.

A representative list of micro-projects is given here. The concerned faculty can add similar micro-projects based on student activities (chart/presentation/report/model/animation):

A representative list of micro-projects is given here. The concerned faculty can add similar micro-projects based on student activities (chart/presentation/report/model):

1. Take a real life component, prepare its 3-D model with proper dimensions. Identify the boundary condition and do FEA of the same.
2. Prepare presentation of Graphics standard which has not been included in the syllabus.
3. Write DDA and Bresenham's algorithms for Line and Circle in to Octave/MATLAB or similar software.
4. Solve 2-D geometric transformation in Open office/Excel.
5. Compare difference in result by changing mesh element type by keeping other parameters and boundary conditions same.
6. Solve 1-D problems with the help of elimination approach and penalty approach using C programme.

### 13. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Book	Author	Publication
1.	CAD / CAM: Theory and Practice	Ibrahim Zied	Tata Mcgraw- Hill.
2.	CAD / CAM and Automation	Farazdak Haideri	Nirali Prakashan
3.	CAD/CAM: Principles and Applications	P N Rao	McGraw Hill Education
4.	Computer Graphics	Hearn E J and Baker M P	Pearson
5.	Introduction to Finite Elements in Engineering	Chandrupatla T A	PHI
6.	Finite Element Analysis	S. S. Bhavikatti	New Age Publishers

### 14. SOFTWARE/LEARNING WEBSITES

1. <https://nptel.ac.in/courses/112102101>
2. <https://www.youtube.com/watch?v=A3i2qFx7d5g>
3. <https://www.programmingsimplified.com/c/graphics.h#functions>
4. <https://youtu.be/z5CuHzUPnYY?si=DhrYst6ZTWcRGII>
5. <https://youtu.be/z0sNZiYq6tI?si=t8U1h9YLcfboJExR>
6. [https://www.youtube.com/playlist?list=PLuAADu3OvBt5OXDZzk9Lq57dAzR\\_nC3mH](https://www.youtube.com/playlist?list=PLuAADu3OvBt5OXDZzk9Lq57dAzR_nC3mH)
7. [https://www.youtube.com/playlist?list=PLYwpaL\\_SFmcAtxMe7ahYC4ZYjQHun\\_b-T](https://www.youtube.com/playlist?list=PLYwpaL_SFmcAtxMe7ahYC4ZYjQHun_b-T)
8. [https://www.tutorialspoint.com/computer\\_graphics/line\\_generation\\_algorithm.htm](https://www.tutorialspoint.com/computer_graphics/line_generation_algorithm.htm)
9. [https://www.tutorialspoint.com/computer\\_graphics/circle\\_generation\\_algorithm.htm](https://www.tutorialspoint.com/computer_graphics/circle_generation_algorithm.htm)
10. <https://www.youtube.com/playlist?list=PLrOpxdi4yBrFO-wajK1-9S5qK3dVKQ4hZ>

### 15. PO-COMPETENCY-CO MAPPING

Semester IV	Computer Aided Design ( 4356503 )						
	POs						
Competency & Course Outcomes	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
	Basic & Discipline-specific knowledge	Problem Analysis	Design/ development of solutions	Engineering Tools, Experimentation & Testing	Engineering practices for society, sustainability & environment	Project Management	Life-long Learning
Competency							
CO-1: Appreciate principles and tools for Computer Aided Design.	3	-	-	2	-	-	-
CO-2: Utilize graphic standards, data exchange formats, and geometric transformations for engineering models.	3	2	-	3	-	-	2
CO-3: Utilize parametric representations of curves and surfaces by enabling effective modeling in CAD applications.	3	3	3	3	-	-	-
CO-4: Compare various modeling techniques in CAD.	3	2	2	3	-	-	2
CO-5: Apply Finite Element Analysis (FEA) techniques for structural, thermal and fluid problems of mechanical components.	3	3	3	3	-	-	3

**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
1.	Prof. A. M. Girach	G. P. Junagadh	7990084805	ayaz.girach@gpjun.gujgov.edu.in

### BOS RESOURCE PERSONS

Sr. No.	Name and Designation	Institute	Contact No.	Email
1.	Dr. S. H. Sundarani	HOD Mech. Engg. G.P.	9227200147	gpasiraj@gmail.com
2.	Dr. Hamir Sapramer	HOD Mech. Engg. G.P.	9426587197	merhamir@yahoo.com
3.	Prof. N.G.Parmar	R.C.T.I. Ahmedabad	9426333054	ngparmar201@gmail.com
4.	Prof. B.D.Parmar	Subject Expert, G. P.	9998910580	bdpar@yahoo.com