

GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)**Competency-focused Outcome-based Green Curriculum-2023 (COGC-2023)**
Semester-VI**Course Title: Computer Integrated Manufacturing**
(Course Code: 4366502)

Diploma program in which this course is offered	Semester in which offered
Mechanical Engineering (CAD/CAM)	6 th Semester

1. RATIONALE

The "Computer Integrated Manufacturing" (CIM) course equips mechanical engineering students with the skills needed for modern manufacturing environments. By integrating CAD, CAM, automation, and data management, CIM creates a seamless production system, preparing students to meet industry demands.

The course emphasizes practicals that mirror real-world practices, allowing students to apply theoretical knowledge to real scenarios. This hands-on experience with modern tools ensures students are proficient in both theory and application, making them industry-ready.

With a balanced blend of practical and theoretical elements, the course fosters innovation and adaptability in students, enabling them to excel in the rapidly evolving manufacturing landscape. Through this comprehensive approach, students gain the technical proficiency needed to contribute effectively to advanced manufacturing environments.

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 Computer Integrated Manufacturing (CIM), including the integration of CAD/CAM systems and automation for efficient production processes.
- Proficiently utilize advanced CAD and CAM techniques, additive manufacturing, CNC machining, and automation tools to design, manufacture, and optimize engineering components and systems.
- Apply Design for Manufacturing (DFM), Design for Assembly (DFA), and data exchange standards to enhance product development and ensure seamless communication across manufacturing platforms.

3. COURSE OUTCOMES (COs)

The practical exercises, 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	Apply DFM and DFA principles to optimize product design for manufacturability and assembly.
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CO-2	Demonstrate proficiency in integrating CAD models into CAM software and performing post-processing for CNC machines.
CO-3	Utilize advanced CAD techniques to create 3D assemblies.
CO-4	Employ advanced CAM techniques to manufacture components.
CO-5	Implement 3D printing technology to design and produce parts.
CO-6	Demonstrate Arduino-based DIY projects and infer the application of AI in CIM.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P/2)	Examination Scheme				
L	T	P	C	Theory Marks		Practical Marks		Total Marks
				CA	ESE	CA	ESE	
0	0	4	2	NA	NA	25	25	50

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)	Appro x. Hrs.	Related COs
01	Preparatory Activity <ul style="list-style-type: none"> ○ Overview of CIM and its importance in modern manufacturing. ○ List and comparison of key features of different CAD/CAM software, evaluating their strengths and weaknesses 	02	All
02	Introduction to Product design <ul style="list-style-type: none"> ○ Study the product lifecycle from the initial concept to manufacturing. ○ Design for Manufacturing (DFM) and Design for Assembly (DFA) principles in product design. 	04	CO-1
03	Integration of CAD and CAM <ul style="list-style-type: none"> ○ Understand data exchange standards (e.g., IGES, STEP, etc.) and practice importing CAD models into CAM software. ○ Understand and perform post-processing for various CNC machines (e.g., Haas, Fanuc, etc.) using any popular CAM software (e.g., Master cam, Siemens NX, Solid CAM, Solid works, Fusion 360, etc.) 	04	CO-2
04	Advanced CAD Techniques <ul style="list-style-type: none"> ○ Choose an existing useful assembly or design a new product with 2 to 4 parts, considering factors like complexity, manufacturability, and relevance (e.g. Jigs, Fixtures, vise assembly, Clamps, Cotter joint, knuckle joint, , wheel & axle assembly, Shaft & pulley assembly, simple gearbox, coupling mechanism, Sliding linear guide mechanism, Four-Bar Linkage Mechanism, Motor Mounting Bracket, Screw jack, Tool post, etc.). ○ Apply DFA and DFM principles to modify & optimize the design for assembly and manufacturing. 	14	CO-3

	<ul style="list-style-type: none"> ○ Create precise 3D models of each component, considering manufacturability and fit. ○ Apply geometric dimensioning and tolerancing (GD&T) to ensure proper functionality and interoperability of parts. ○ Perform realistic rendering, animations, and motion constraints to simulate product behavior and identify & resolve mechanical issues. ○ Generate 2D production drawings for each component. 		
05	<p>Advanced CAM Techniques</p> <ul style="list-style-type: none"> ○ Select important components from the assembly designed in practical number 04. ○ Develop a manufacturing process plan specifying required machining operations & its sequence, tools, and equipment, etc. ○ Choose suitable operations for CNC machining to manufacture the component. ○ Import 3D models into CAM software and use advanced toolpath strategies for efficient machining. ○ Simulate toolpath and program execution to identify & correct potential errors before machining. ○ Optimize machining processes and explore the feasibility of automation in CNC machining, including the use of robotics and computer-integrated inspection systems like CMM. ○ Produce the part with operations on machines. 	14	CO-4
06	<p>Additive manufacturing and 3D printing</p> <ul style="list-style-type: none"> ○ Study different types of 3D printing technologies, including FDM, SLA, SLS, and more. ○ Understand the applications of additive manufacturing in various industries. ○ Compare additive manufacturing with traditional manufacturing methods, focusing on material usage, cost, production time, and design flexibility. ○ Design and create 3D model of a simple part and produce it on a 3D printer (Students Batch activity) 	08	CO-5
07	<p>Introduction to Arduino Uno for Automation and Control</p> <ul style="list-style-type: none"> ○ Gain hands-on experience with Arduino Uno / Raspberry Pi, learning basic electronics. ○ Study and demonstration of any advanced project like a Arduino based DIY 3D printer, DIY CNC machine, Pick and Place Robotic Arm, a temperature monitoring system, motor control, IoT-enabled machine monitoring system etc. integrating Arduino/ Raspberry Pi with mechanical systems to mimic industrial automation. 	08	CO-6
08	<p>Introduction to AI and Machine Learning in Manufacturing</p> <ul style="list-style-type: none"> ○ Learn the basics of AI and machine learning, focusing on their relevance in manufacturing. 	02	CO-6
Total (Hours)		56	

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

Criteria	Excellent: 5	Very Good: 4	Good: 3	Fair: 2
Knowledge	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%.
Correctness	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.
Participation	Excellent focused attention in the exercise.	Moderately focused attention on exercise.	Focused limited attention in the exercise.	Participation is minimum.
Punctuality	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.
Timely submission	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.

Sr. No.	Equipment Name	PrO. No.
1.	Computer Systems: Computers with the latest configurations suitable for running CAD software efficiently.	All
2.	Software Tools: 3D CAD/CAM software such as Autodesk Fusion 360, Siemens NX, SolidCAM, SolidWorks, and Mastercam. Preferably use free access software like Fusion 360.	3,4,5,6
3.	DIY Kits: Arduino UNO or Raspberry Pi kits for hands-on projects.	7
4.	CNC Machines: CNC machines like lathe, milling, etc. to perform necessary operations.	3,4,5,6

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 1st year
- II. 'Organization Level' in 2nd year.
- III. 'Characterization Level' in 3rd year.

8. SUGGESTED STUDENT ACTIVITIES

Sr. No.	Activity.
1.	Case Study Preparation: Compile case studies showcasing successful implementations of CIM in real-world manufacturing settings, focusing on challenges and outcomes.
2.	Software Comparison: Research and compare popular CAD/CAM software used in CIM, evaluating features, pricing, and applications across different industries.
3.	Programming Implementation: Implement and visualize data exchange standards (e.g., IGES, STEP) in a programming environment to understand their role in integrating CAD and CAM.
4.	Graphic Standards Poster: Create a poster or infographic detailing the importance of graphic standards in CIM, illustrating examples of various standards and their applications.
5.	Simulation Exploration: Use simulation tools to illustrate advanced CNC machining processes, showcasing the integration of CAM with CAD
6.	Research and Presentation: Investigate the application of DFM and DFA principles in product design and present case studies that demonstrate their importance
7.	Parametric Design Experiment: Experiment with feature-based modeling to create designs that can be easily modified, focusing on DFM and DFA considerations.
8.	CNC Machining Analysis: Analyze a CNC machining process and present findings on the optimization of machining operations and toolpath strategies
9.	AI and Automation Research: Research the role of AI and machine learning in manufacturing, presenting findings on how these technologies are applied within CIM

9. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Book	Author	Publication
1.	Computer Integrated Manufacturing	A. ALAVUDEEN, N. VENKATESHWARAN	PHI, India
2.	CAD / CAM: Theory and Practice	Ibrahim Zied	Tata Mcgraw- Hill.
3.	CAD/CAM: Principles and Applications	P N Rao	McGraw Hill Education
4.	Fusion 360 for Makers	Lydia Sloan Cline	Shroff/Maker Media
5.	CNC Fundamentals and Programming	P.M.Agrawal, Dr,V.J.Patel	Charotal

6.	CNC MACHINE (Operating and Programming)	Ajay Dhamande	Self
7.	Design for Manufacturing	James G Bralla	McGraw Hill Education
8.	CAD/CAM/CIM	Dr. K.C. Jain and Vikas Gohil	Khanna Publishers
9.	Inexpensive CNC projects	Robert J Davis II	Kindle Edition
10.	Additive Manufacturing Technologies	Ian Gibson, David Rosen, Brent Stucker	Springer

10. SOFTWARE/LEARNING WEBSITES

- <https://www.youtube.com/playlist?list=PLFCTgdiT5-kLBNvrkUNy63Gu1tWdRuKkr>
- https://www.youtube.com/watch?v=Do_C_NLH5sw
- <https://www.autodesk.com/learn/ondemand/curated/milling-basics>
- <https://www.autodesk.com/learn/ondemand/tutorial/create-a-setup-in-fusion-for-turning>
- <https://www.youtube.com/watch?v=a42znmU6BLE>
- <https://projecthub.arduino.cc/>
- <https://github.com/grbl/grbl>
- <https://www.instructables.com/DIY-CNC-Router/>
- <https://diymachining.com/arduino-cnc-mini-mill/>
- <https://www.instructables.com/Homebuilt-DIY-CNC-Router-Arduino-Based-GRBL/>
- https://www.youtube.com/watch?v=c8_Gh1HX72E
- <https://www.youtube.com/watch?v=l6XFxAMXBcY>

11. PO-COMPETENCY-CO MAPPING

Semester VI	Computer Integrated Manufacturing (4366502)						
	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: Apply DFM and DFA principles to optimize product design for manufacturability and assembly.	3	-	-	1	-	-	3
CO-2: Demonstrate proficiency in integrating CAD models into CAM software and performing post-processing for CNC machines.	3	2	-	2	-	-	-
CO-3: Utilize advanced CAD techniques to create 3D assemblies.	3	3	3	3	-	-	-

CO-4: Employ advanced CAM techniques to manufacture components.	3	3	3	3	-	-	-
CO-5: Implement 3D printing technology to design and produce parts.	3	3	3	3	-	-	-
CO-6: Demonstrate Arduino-based DIY projects and infer the application of AI in CIM.	3	-	-	2	-	-	-

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

12. COURSE CURRICULUM DEVELOPMENT COMMITTEE (GTU RESOURCE PERSONS)

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BOS RESOURCE PERSONS

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