SCHEME :K

Name :____________________________
Roll No.:_________ Year : 20 ___ 20 __
Exam Seat No. :____________________

LABORATORY MANUAL FOR

COMPUTER INTEGRATED MANUFACTURING SYSTEMS (316359)

MECHANICAL ENGINEERING GROUP

MAHARASHTRA STATE BOARD OF
TECHNICAL EDUCATION, MUMBAI
(Autonomous)(ISO21001:2018)(ISO/IEC27001:2013)

Maharashtra State
Board of Technical Education, Mumbai

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To provide high quality technical and managerial manpower, information and consultancy services to the industry and community to enable the industry and community to face the challenging technological & environmental challenges.

A Practical Manual for

Computer Integrated Manufacturing Systems (316359)

Semester – VI

"K- SCHEME"

Diploma in Mechanical Engineering

Maharashtra State Board of Technical Education, Mumbai

(Autonomous) (ISO 21001:2018) (ISO/IEC 27001:2013)

MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION

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MAHARASHTRA STATE
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Certificate

This is to certify that Mr. / Ms .... Roll No………………………. of Sixth Semester of Diploma in ………………………………………………………. of **Institute Name:** ………………………………………………………….. (**Institute Code**:………………..) has completed the term work satisfactorily in the course **Computer Integrated Manufacturing Systems (316359)** for the academic year 20…… to 20…..... as prescribed in the curriculum.

Place: ………………. Enrollment No.: …………………

Date: …..................... Exam Seat No.: …………………....

Course Teacher **Head of the Department** **Principal**

Seal of the Institute

Preface

The primary focus of any engineering laboratory/ field work in the technical education system is to develop the much-needed industry-relevant competencies and skills. With this in view, MSBTE embarked on this innovative 'K' Scheme curriculum for engineering diploma programmes with the National Education Policy 2020 (NEP-2020) and outcome-based education as the focus, and accordingly, a relatively large amount of time is allotted for the practical work. This displays the great importance of laboratory work making each teacher, instructor, and student realize that every minute of the laboratory time need to be effectively utilized to develop these outcomes, rather than doing other mundane activities. The practical skills are difficult to develop through the 'chalk and duster' activity in the classroom situation. Accordingly, the 'K' scheme laboratory manual development team designed the practical to ***focus*** on the ***outcomes***, rather than the traditional age-old practice of conducting practicals to 'verify the theory' (which may become a byproduct along the way).

This laboratory manual is designed to help all stakeholders, especially the students, teachers, and instructors, to develop in the student the pre-determined outcomes. It is expected from each student that at least a day in advance, they have to thoroughly read through the concerned practical procedure that they will do the next day, and understand the minimum theoretical background associated with the practical. Every practical in this manual begins by identifying the competency, industry relevant skills, course outcomes and practical outcomes which serve as a key focal point for doing the practical. The students will then become aware of the skills they will acquire through the procedure shown there and the necessary precautions to be taken, which will help them apply them to solving real-world problems in their professional lives.

This manual also provides guidelines to teachers and instructors to effectively facilitate student-centered lab activities through each practical exercise by arranging and managing necessary resources in order that the students follow the procedures and precautions systematically ensuring the achievement of outcomes in the students.

A comprehensive understanding of Computer Integrated Manufacturing (CIM) is essential for modern manufacturing engineering. This subject integrates concepts such as automated material handling, CNC and PLC-based machine control, robotics, flexible manufacturing systems, CAD/CAM integration, and real-time production planning. It also involves advanced digital tools like Computer-Aided Process Planning (CAPP) for structured process design and Computer-Aided Quality Control (CAQC) for automated inspection, measurement, and quality assurance. These integrated technologies enable industries to achieve high precision, reduced lead time, improved productivity, and seamless data flow across the manufacturing environment, supporting the transition toward Industry 4.0 and smart factory operations.

The practical manual development team sincerely appreciates the efforts of MSBTE for initiating curriculum development and supporting its implementation. We acknowledge the valuable contributions of course coordinators, subject experts, and laboratory instructors who guided the preparation of this manual under the K Scheme. Although every effort has been made to ensure clarity and accuracy, minor errors may still remain in this first edition. Constructive feedback and suggestions from faculty and students are warmly welcomed and will help us enhance the quality of future editions.

Lab Manual Development Team

Programme Outcomes (POs) to be achieved through Practical of this Course

Following POs are expected to be achieved through the practicals of the Heating Ventilation Air Conditioning course.

PO1. Basic and discipline-specific knowledge: Apply knowledge of basic mathematics, science and engineering fundamentals and engineering specialization to solve the mechanical engineering problems.

PO2. Problem analysis: Identify and analyze well-defined mechanical engineering problems using codified standard methods.

PO3. Design/ development of solutions: Design solutions for well-defined technical problems and assist with the design of system components or processes to meet specified needs in mechanical engineering.

PO4. Engineering Tools, Experimentation and Testing: Apply modern mechanical engineering tools and appropriate technique to conduct standard tests and measurements.

PO5. Engineering practices for society, sustainability and environment: Apply appropriate technology in context of society, sustainability, environment and ethical practices.

PO6. Project Management: Use engineering management principles individually, as a team member or a leader to manage projects and effectively communicate about well defined engineering activities in diverse and multidisciplinary fields.

PO7. Life-long learning: Ability to analyze individual needs and engage in updating in the context of technological changes in mechanical engineering.

List of Industry-Relevant Skills

The practical exercises included in this laboratory manual are designed to help students develop industry-relevant skills and competencies in the areas of alternative energy sources and energy management in industries. Through the completion of these practicals, students will be able to:

1. Effectively use energy audit instruments in a given shop or section to perform industrial energy audits involving data collection, measurement, analysis, and report preparation for achieving sustainable energy management.
2. Measure illumination levels accurately in various workplace environments using a lux meter.
3. Record and analyse energy meter readings, apply the CUSUM (Cumulative Sum) technique, and interpret variations in electrical energy consumption.
4. Use various measuring instruments to evaluate the performance of solar modules at different tilt angles and orientations, and design rooftop solar power systems for domestic buildings or small office applications.
5. Understand the components and working principles of geothermal, ocean thermal, and wind power plants, and relate this knowledge to potential careers in renewable energy and power generation.

Practical-Course Outcome matrix

Course Outcomes (COs):

Studentswillbeabletoachieve&demonstratethefollowingCOsoncompletionofcoursebased learning;

- CO1 - Interpret the components of CIM architecture for a given application.
- CO2 - Apply CAD techniques to design simple mechanical parts.
- CO3 - Apply CAM techniques to optimize machining processes.
- CO4 - Use different software and hardware in CIM efficiently.
- CO5 - Develop program to manage robotic / automation system using relevant software.

Sr. No.	Laboratory Practical Titles	CO 1.	CO 2.	CO 3.	CO 4.	CO 5.
1	*Drawing of simple mechanical parts modeled using the drafting workbench of CAD Software.	√	√	-	-	-
2	*Development of the simple mechanical part by using the geometric modeling workbench (Any 3 D modeling software).	-	√	-	-	-
3	Generation of Bill of Material (BOM) and other data using CAD Software.	-	√	-	-	-
4	Computer-Aided Process Plan for the selected part using various CAPP Software.	√	√	-	-	-
5	*CNC code for a simple machining operation using a CNC Machine/Trainer/Simulator.	√	√	√	-	-
6	Inspection of the part using available CAQC software.	-	-	√	-	-
7	MRP (Material Resource Planning) software for CIM and assembly.	√	-	√	√	-
8	*Layout of network topology and network hardware/network software for given situation.	-	-	-	√	-
9	*Design simple manufacturing cells (e.g., machining cell, assembly cell) using available CAD software.	√	√	√	-	√
10	*PLC Programming to control a simple automation system.	-	-	-	-	√
11	Programming of a robot to perform simple task.	-	-	-	-	√
12	*Use Teach Pendent/Offline Programming/Simulation Software to program a robotic arm to perform pick and place and stacking of objects.	√	-	-	-	√
13	Elements of FMS and its nature of controlling by computer through Video film/actual demonstration (plant visit).	-	-	√	-	√
14	Various elements of Robotic Systems, types of robots, their configuration, and the nature of controlling by computer through video/actual demonstration (plant visit).	-	-	-	√	√
15	*Establish networking between CNC Machines, computers and supported peripherals of your Institute to exchange the manufacturing data and produce simple component.	-	-	-	√	-

Guidelines to Teachers

1. **The teacher needs to ensure that a dated logbook** for the whole semester, apart from the laboratory manual, is maintained by every student, which s/he has to **submit for assessment to the teacher** in the next practical session.
2. There will be two sheets of blank pages after every practical for the student to report other matters (if any), which are not mentioned in the printed practical.
3. For difficult practical if required, teacher could provide the demonstration of the practical emphasizing of the skills which the student should achieve.
4. Teachers should give opportunity to students for hands-on after the demonstration.
5. Assess the skill achievement of the students and Cos of each unit.
6. One or two questions ought to be added in each practical for different batches. For this teacher can maintain various practical-related question banks for each course.
7. If some repetitive information like data sheet, use of software tools etc. has to be provided for effective attainment of practical outcomes, they can be incorporated in Appendix.
8. For effective implementation and attainment of practical outcomes, teacher ought to ensure that in the beginning itself of each practical, students must read through the complete write-up of that practical sheet.
9. During practical, ensure that each student gets chance and takes active part in taking observations/ readings and performing practical.
10. Teacher ought to assess the performance of students continuously according to the MSBTE guidelines.

Instructions for Students:

1. For incidental writing on the day of each practical session every student should maintain a ***dated log book*** for the whole semester, apart from this laboratory manual which s/he has to ***submit for assessment to the teacher*** in the next practical session.
2. For effective implementation and attainment of practical outcomes, in the beginning itself of each practical, student need to read through the complete write-up including the practical related questions and assessment scheme of that practical sheet.
3. Student ought to refer the data books, IS codes, Safety norms, Technical Manuals,etc.
4. Student should not hesitate to ask any difficulties they face during the conduct of practical.

Content Page

List of Practical and Progressive Assessment Sheet

S. No.	Laboratory Practical Titles	Page No.	Date of performance	Date of submission	FA-PR Marks (25)	Dated sign. of teacher	Remarks (if any)
1	*Drawing of simple mechanical parts modeled using the drafting workbench of CAD Software.						
2	*Development of the simple mechanical part by using the geometric modeling workbench (Any 3D modeling software).						
3	Generation of Bill of Materials (BOM) and other data using CAD Software.						
4	Computer-Aided Process Plan for the selected part using various CAPP Software.						
5	*CNC code for a simple machining operation using a CNC Machine/Trainer/Simulator.						
6	Inspection of the part using available CAQC software.						
7	MRP (Material Resource Planning) software for CIM and assembly.						
8	*Layout of network topology and network hardware/network software for the given situation.						
9	*Design simple manufacturing cells (e.g., machining cell, assembly cell) using available CAD software.						
10	*PLC Programming to control a simple automation system.						
11	Programming of a robot to perform a simple task.						
12	*Use Teach Pendant/Offline Programming/Simulation Software to program a robotic arm to perform pick and place and stacking of objects.						
13	Elements of FMS and its nature of controlling by computer through Video film/actual demonstration (plant visit).						

14	Various elements of Robotic Systems, types of robots, their configuration, and the nature of controlling by computer through video/actual demonstration (plant visit).						
15	*Establish networking between CNC Machines, computers and supported peripherals of your Institute to exchange the manufacturing data and produce simple component.						

Note: To be transferred to Proforma of CIAAN-2023.

A suggestive list of LLOs is given in the above table. More such LLOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practical marked as '*' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.

Practical No.1

*Drawing of a Simple Mechanical Parts Modelled using the Drafting Workbench of CAD Software

I. Practical Significance

This experiment develops the student's ability to convert 3D mechanical models into detailed 2D engineering drawings with correct projections, dimensions, and tolerances. In a Computer-Integrated Manufacturing (CIM) environment, this translation from virtual model to standardized drawing ensures seamless data exchange between design, analysis, and production stages. Students learn to apply international drawing standards (ISO 128, ASME Y14.5, BIS SP:46), the foundation for digital manufacturing documentation, CNC programming, and inspection automation.

II. Industry/Employer Expected Outcome(s)

Apply skills related to Computer-Integrated Manufacturing Systems in a real-world manufacturing environment.

III. Course Level Learning Outcomes (COs)

CO1 - Interpret the components of CIM architecture for a given application

CO2 - Apply CAD techniques to design simple mechanical parts.

IV. Laboratory Learning Outcomes (LLOs)

LLO 1.1– Convert 3D modelled components into detailed 2D engineering drawings with proper views and projections.

LLO 1.2 - Use dimensioning and tolerances as per ISO, ASME, or BIS standards

V. Relative Affective Domain Outcomes

- Shows disciplined behavior, file organization, and consistent workflow practice during drafting activities
- Maintain tools, models, and equipment.
- Participate actively, support peers when needed
- Follows laboratory safety and ethical practices.

VI. Minimum Theoretical Background with Diagram

CAD Drafting Concept: CAD (Computer-Aided Design): Creation of precise geometry and annotations through licensed software, 3D-to-2D Conversion, Extraction of orthographic and isometric projections from parametric solid models.

Standards:

ISO 128 – General principles of presentation.

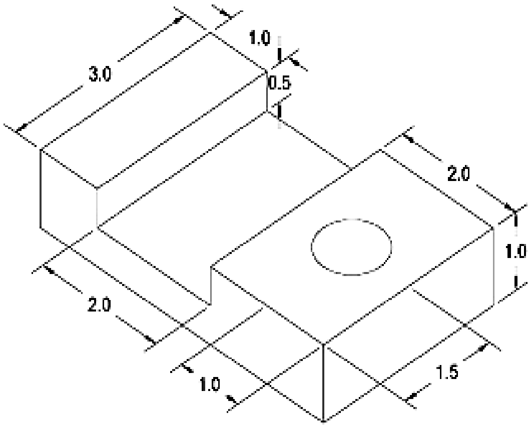
ASME Y14.5 – Dimensioning & tolerancing conventions.

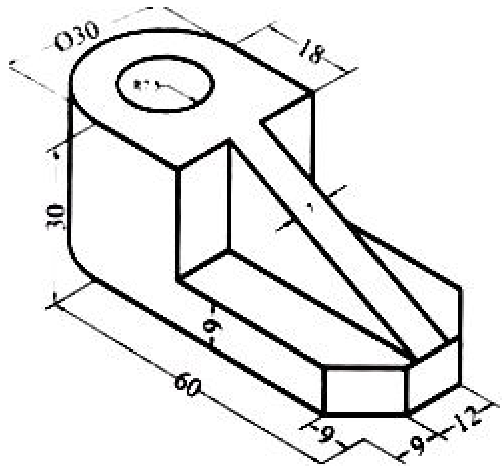
BIS SP:46 – Engineering drawing practices.

Projection Principles

1. Orthographic Projections: Represent front, top, and side views in perpendicular planes.
2. Isometric Projection: 3D pictorial view inclined at 120° for visualization.
3. First-Angle vs Third-Angle Method: Defined by symbol ⟲ on title block.
4. Dimensioning & Tolerance
5. Linear/Angular Dimensions: Indicate true sizes and relationships.
6. Limits & Fits: Express acceptable manufacturing variation (e.g., H7/g6).
7. Geometric Tolerances: Specify allowable variation in form & orientation (flatness, parallelism, position, etc.).

(The student should draw the basic 2D diagram of the given Sample drawing / Any other drawing provided by the subject teacher)





VII. Experimental Setup:

1. **System:** Intel i7 PC (16 GB RAM, Windows 10/11) / Any other suitable system
2. **Licensed Software:** CATIA V5 R21 / SolidWorks 2022 / AutoCAD 2023/ Any other available Software
3. **Component:** Simple 3D mechanical part (e.g., L-bracket, flanged bushing).
4. **Units:** Metric (mm); Sheet A3 size; Scale 1:1.

VIII. Required Resources:

S. No.	Name of Resource	Suggested Specification	Quantity
1	Hardware	Workstation with graphics support	1
2	Licensed Software	Drafting & Part Design modules	1
4	Standards (Manuals)	ISO 128, ASME Y14.5, BIS SP:46	1

IX. Precautions to be Followed

1. Ensure sheet units and projection standards are selected before starting.
2. Fully constrain sketches before generating drawing views.
3. Apply dimensions as per drawing hierarchy (no duplicate/over-dimensioning).
4. Save file regularly to prevent data loss

X. Procedure

1. Launch CAD software → Start a new Drawing Sheet.
2. Import or model the given 3D component**.**
3. Select projection method (First or Third Angle).
4. Generate Front, Top, and Side views automatically using *View Projection* commands.
5. Insert dimensions using smart/aligned dimension tools.
6. Apply tolerances and GD&T symbols (as per ISO/ASME).
7. Fill the title block with part name, material, scale, author, and date.
8. Check drawing for accuracy, projection alignment, and standard compliance.
9. Save as .dwg / .pdf and print for evaluation.

XI. Observations and Calculations

Observation Type	Remarks
Projection Method Used (First/Third Angle)	
Views Generated (Front, Top, Side, Isometric)	
Drawing Scale Used	
Standard Followed (ISO / ASME / BIS SP:46)	
Dimensions Applied Correctly (Yes/No)	
Tolerances Applied (Type & Value)	
GD&T Symbol Applied (e.g., ⊥, ‖, ⌀, ⌖)	
Surface Finish Symbol Used	
Title Block Completed (Yes/No)	
File Saved As (File Name)	

XII. Results

XIII. Interpretation of Results

XIV. Conclusion and Recommendations

XV. Practical Related Questions

Note: The following are a few sample questions for reference. Teachers must design more such questions to ensure the achievement of the identified CO.

1. State steps in importing the 3D model into the active workbench.
2. State any two GD&T symbols and their application.

[Space for Answer]

XVI. References/ Suggestions for Further Reading

1) https://youtu.be/OgyP6OgHEIo
2) https://www.youtube.com/watch?v=XJjc923jiKk
3) https://www.youtube.com/watch?v=Zy1HFiraQQQ
4) https://www.youtube.com/watch?v=PSOPggIB51o

XVII. Rubrics for Assessment Scheme

Performance Indicator	**Weightage**
Process Related (15 Marks)	**(20 %)**
Use of CAD drafting tools & projection method	10%
Discipline, layout, neatness & file organization	10 %
Product Related (10 Marks)	**(80 %)**
Dimensional accuracy & standard-compliant tolerancing	40%
Quality of final drawing conclusion & explanation	20%
Viva / Questions	30%
Total	**100%**

Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 2

*Development of a Simple Mechanical Part Using the Geometric Modelling Workbench (Any 3-D Modelling Software)

I. Practical Significance

This experiment enables students to design and visualize mechanical components in three dimensions using parametric and feature-based modelling tools. The 3-D model forms the basis for all downstream activities in Computer Integrated Manufacturing (CIM). By completing this experiment, students learn to generate 3-D models, develop corresponding orthographic and isometric projections, and apply Geometric Dimensioning & Tolerancing (GD&T) principles for accurate, standardized part specification.

II. Industry/Employer Expected Outcome(s)

Apply skills related to Computer-Integrated Manufacturing Systems in a real-world manufacturing environment.

III. Course Level Learning Outcomes (COs)

CO2- Apply CAD techniques to design simple mechanical parts

IV. Laboratory Learning Outcomes (LLOs)

LLO 2.1: Develop orthographic projections (front, top, and side views) and isometric projections for component visualization.

LLO 2.2: Apply GD&T principles in technical drawings for accurate part specifications.

V. Relative Affective Domain Outcomes

- Demonstrates responsibility and discipline in organizing part models and drawing files.
- Works cooperatively with peers and follows lab safety and ethical norms
- Collaborate as a team member in academic exercises.

VI. Minimum Theoretical Background

1) Geometric Modelling

Wireframe Modelling: Represents geometry through vertices and edges.

Surface Modelling: Defines external surfaces without volume.

Solid Modelling: Defines complete geometry with mass and physical properties.

Parametric Modelling: Uses dimensions and constraints to control design intent.

2) Projection Principles

Orthographic Projections: Show object views (Front, Top, Side) on perpendicular planes used for manufacturing drawings.

Isometric Projection: 3-D pictorial representation with axes 120° apart for visualization and verification.

3) Geometric Dimensioning & Tolerancing (GD&T)

GD&T establishes uniform standards to communicate allowable variations in form, orientation, and position

GD&T Symbol	Characteristic	Example Use
⏥	Flatness	Ensures flat contact surfaces
⊥	Perpendicularity	Controls axis orientation
‖	Parallelism	Controls feature alignment
⌀	Circularity	Ensures roundness
⌖	Position	Controls hole location accuracy

VII. Experimental Setup:

1. **Hardware:** Intel i7/i9 PC (16 GB RAM min, GPU enabled).
2. **Licensed Software:** CATIA V5, SolidWorks 2022, Creo Parametric or Fusion 360.
3. **Task:** Model a simple mechanical part (e.g., L-bracket, flanged bushing, base plate).
4. **Units:** Metric (mm).
5. **Sheet Template:** ISO A3 with first-angle projection.

VIII. Required Resources /Apparatus/Equipment with specification

S. No.	Name of Resource	Description	Quantity
1	Hardware	Workstation with CAD software	1
2	Licensed Software	Part Design & Drafting Workbenches	1
3	Reference Material	Engineering drawing of a sample part	1
4	Standards	ISO 1101, ASME Y14.5, BIS SP:46 – 2003	1

IX. Precautions to be Followed

1. Ensure the correct unit system is set before sketching.
2. Fully constrain and dimension sketches to maintain model accuracy.
3. Apply GD&T with reference to the correct datum features.
4. Save incremental versions and ensure model integrity

X. Procedure

1. Launch the CAD software and open Part Design (3-D Modelling) workbench.
2. Create a new part and select an appropriate base plane (XY/YZ/XZ).
3. Create a 2-D Sketch and define geometry with constraints & dimensions.
4. Use Pad/Extrude**,** Revolve, or Sweep commands to create the solid model.
5. Add features such as holes, fillets, chamfers, ribs, and patterns.
6. Switch to Drafting Workbench
7. Apply dimensions and GD&T symbols as per ISO/ASME standards.
8. Include title block**,** material, scale, and projection symbol.
9. Verify drawing consistency, save in `CATPart` / SLDPRT, and export drawing as `.PDF` or `.DWG`

XI. Observations Table

Observation Parameter	Remarks
Projection Views Generated (Front / Top / Side / Isometric)	
Projection Method Used (First Angle / Third Angle)	
Principal Dimensions Applied Correctly (Yes/No)	
GD&T Symbol(s) Applied (e.g., ⊥, ∥, ⌀, ⌖)	
Datum Reference Frame Identified (A-B-C)	
Surface Finish or Feature Notes Added (Yes/No)	
Final Drawing Template Used (A3, Scale, Material, Title Block)	
Filename Saved As	

XII. Results

XIII. Interpretation of Results

XIV. Conclusion and Recommendations

XV. Practical Related Questions

Note: Below are a few sample questions for reference. Teachers must design more such questions to ensure the achievement of the identified CO.

1. Explain the importance of an isometric view in part visualization
2. State the meaning and application of ⊥ (perpendicularity) and ⌖ (position).

[Space for Answer]

XVI. References / Further Reading

1) https://youtu.be/F-ObgYKb3rw
2) https://youtu.be/eOFD165H118
3) https://youtu.be/RhsBEoyeTB8
4) https://youtu.be/bChytx8PHvU

XVII. Rubrics for Assessment Scheme

Performance Indicator	**Weightage**
Process Related (15 Marks)	**(20%)**
Sketch constraints & feature sequence	10%
Proper use of design intent (parameters, symmetry)	10%
Product Related (10 Marks)	**(80%)**
Accuracy of 3D geometry	40%
Correct application of GD&T and views in drawing	20%
Viva / Questions	20%
Total	**100%**

<table>
<tr><th colspan="3">Marks Obtained</th><th>Dated signature of Teacher</th></tr>
<tr><th>Process Related (15)</th><th>Product Related (10)</th><th>Total (25)</th><td rowspan="2"></td></tr>
<tr><td></td><td></td><td></td></tr>
</table>

Practical No. 3
Generation of Bill of Materials (BOM) and Other Data Using CAD Software

I. Practical Significance

A Bill of Materials (BOM) is a structured list of all components, sub-assemblies, and raw materials required to manufacture a product. In a Computer-Integrated Manufacturing (CIM) environment, automated BOM generation from CAD assemblies ensures data consistency across design, process planning, and ERP/MRP systems. This experiment teaches students how to create assemblies, assign part metadata, generate automatic BOM tables, and format the title block to meet industrial documentation standards.

II. Industry/Employer Expected Outcome(s)

Apply skills related to Computer-Integrated Manufacturing Systems in a real-world manufacturing environment.

III. Course Level Learning Outcomes (COs)

CO2- Apply CAD techniques to design simple mechanical parts.

IV. Laboratory Learning Outcomes (LLOs)

LLO 3.1 Generate a Bill of Materials (BOM) and properly format the title block.

LLO 3.2 Generate automated BOMs from CAD assemblies using built-in tools in software (like SolidWorks, CATIA.

V. Relative Affective Domain Outcomes

- Demonstrates responsibility and organization in file naming and metadata entry
- Participates collaboratively during assembly construction and review.
- Follows lab safety and ethical work practices.

VI. Minimum Theoretical Background

BOM: A BOM is the digital parts list that defines the structure and hierarchy of an assembly.

Types of BOM

1. Design BOM (DBOM): From CAD software; defines 3-D structure.
2. Engineering BOM (EBOM): Includes tolerances, materials, part numbers.
3. Manufacturing BOM (MBOM): Used in ERP; includes routing and operations.
4. Title Block Standards

ISO 7200 / BIS SP: 46 (2003): Defines layout for drawing title blocks.

(Mandatory fields: *Title, Drawing No., Scale, Sheet No., Projection Symbol, Material, Revision, Checked by, Approved by)*

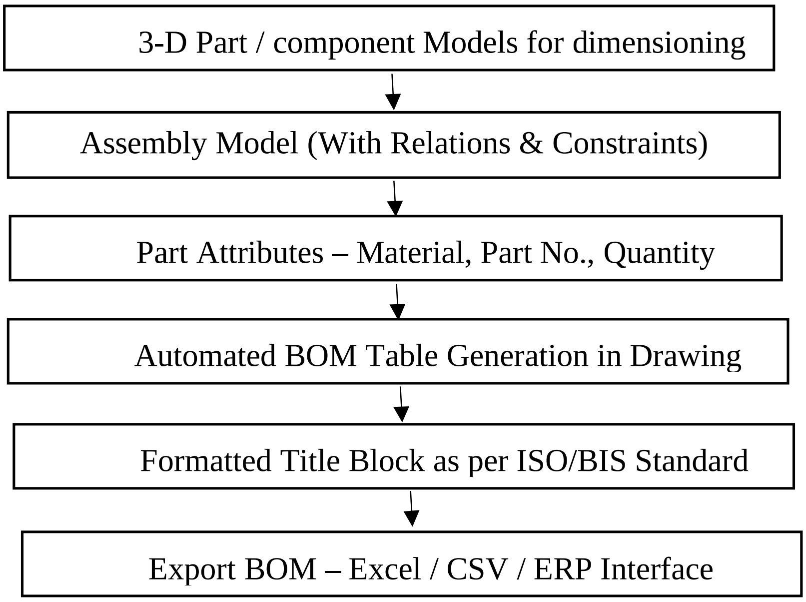


Fig 3.1: CAD to BOM Flow

Part Number	Part Name	Material	Qty	Remarks
1	Base Plate	Mild Steel	1	Main Support
2	Bracket Arm	Mild Steel	1	Welded / Fitted
3	M8 Hex Bolt	Steel	4	Fastening
4	M8 Washer	Steel	4	Standard Hardware

VII. Experimental Setup

1. **Hardware:** Intel i7/i9 PC (16 GB RAM min, GPU enabled).
2. **Software:** SolidWorks 2023 / CATIA V5 / Creo 8 / AutoCAD Mechanical.
3. **Task:** Create a small assembly (3–5 parts) and generate an automatic BOM with formatted title block
4. **Units:** Metric (mm).
5. **Output:** Drawing file

VIII. Required Materials / Resources

Category	Description
Hardware	Workstation with 3-D CAD capability
Software	Part & Assembly Design, Drafting Modules
Reference Material	Sample assembly drawings
Standards	ISO 7200, ISO 7573, BIS SP:46 (2003)
Accessories	Component models for measurement

IX. Precautions to be followed

1. Use Licensed software
2. Ensure every component has a unique part number and a consistent naming convention.
3. Maintain correct assembly constraints to avoid duplicated or floating parts
4. Save files using structured naming

X. Procedure

1. Start Software → Open Assembly Workbench.
2. Insert Components (pre-created 3-D parts).
3. Apply assembly constraints (Mate, Align, Insert) to define relations fully.
4. Assign each component: *Part No.*, Description, Material, Quantity, Revision.
5. Open Drafting/ Drawing Module → Insert Assembly View.
6. From menu → Insert → Tables → Bill of Materials (select table style).
7. Software auto-populates BOM with part details from metadata.
8. Add columns: Part No., Qty, Description, Material, Weight.
9. Format Title Block as per ISO 7200 (BIS SP:46) with required fields.
10. Check alignment, scale, and projection symbol placement.
11. Save & export the drawing and BOM to Excel or CSV format.

XI. Observations:

Sr. No.	Part Name	Part Number	Material	Quantity	Description / Remarks

XII. Results

XIII. Interpretation of Results

XIV. Conclusion and Recommendations

XV. Practical Related Questions

Note: The following are a few sample questions for reference. Teachers must design more such questions to ensure the achievement of the identified CO.

1. State steps in CAD software to automate BOM generation.
2. State the purpose Bills of Materials and draw its structure

[Space for Answer]

XVI. References / Further Reading

1) https://youtu.be/l1c0BcSATIA
2) https://youtu.be/zOCX47_nksA
3) https://youtu.be/DELJwlkQ_Ao

XVII. Rubrics for Assessment Scheme

Performance Indicator	**Weightage**
Process Related (15 Marks)	**(20 %)**
Correct entry of Part Numbers & Metadata	10%
Proper formatting of the title block	10%
Product Related (10 Marks)	**(80 %)**
Correct BOM Generation	40%
Interpretation of BOM output	20%
Viva / Questions	20%
Total	**100%**

Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 4
Computer-Aided Process Plan (CAPP) for a Selected Part Using CAPP Software

I. Practical Significance

Computer-Aided Process Planning (CAPP) serves as the essential link between design (CAD) and manufacturing (CAM/CNC). It automates the creation of process sheets, including machining sequences, operation parameters, work centres, tools, and inspection criteria

II. Industry/Employer Expected Outcome(s)

Apply skills related to Computer-Integrated Manufacturing Systems in a real-world manufacturing environment

III. Course Level Learning Outcomes (COs)

CO1 - Interpret the components of CIM architecture for a given application

CO2 - Apply CAD techniques to design simple mechanical parts.

IV. Laboratory Learning Outcomes (LLOs)

LLO 4.1: Prepare a process plan for a suitable manufacturing operation (e.g. Casting, forming, welding)

LLO 4.2: Develop an optimized sequence of operations for manufacturing a selected part using any suitable CAPP software.

V. Relative Affective Domain Outcomes

- Demonstrates responsibility in documenting process sheets with accuracy.
- Maintains an organized workflow and efficient use of lab software resources.
- Communicates process plan clearly during explanation/presentation.

VI. Minimum Theoretical Background

CAPP: CAPP is a technology that uses software to generate process plans automatically from CAD models or drawings.

Type	Description	Example Application
Variant CAPP	Uses Group Technology & Part Families	Standard parts (shafts, bushings)
Generative CAPP	Uses rules, feature recognition, and AI logic	New / Complex parts
Process Plan	Defines *how* the part will be produced	Sequence of turning → drilling → finishing

Analyze Part Geometry & Material

↓

Identify Manufacturing Operations

↓

Select Machine Tools &WorkCentre

↓

Choose Cutting Tools & Cutting Parameters

↓

Determine Fixture & Clamping Methods

↓

Generating Routing and Operation Sheets

Fig 4.1: Steps in Process Planning

Typical CAPP Output Documents:

1. Routing Sheet (Order of operations and machines)
2. Operation Sheet (Cutting parameters, method)
3. Tool Sheet (Tool numbers, tool holders, inserts)

VII. Experimental Setup

Component	Specification
Hardware	i7/i9 PC with 16+ GB RAM
Software	Kladana Software (Freeware)
Input	CAD Model or Drawing of the selected mechanical part
Output	Routing Sheet + Operation Sheet + Tool Sheet

VIII. Required Resources /Apparatus/Equipment with specification

Type	Description
Hardware	CAD/CAM Workstations
Software	CAPP System (licensed/educational)
Reference Drawing	Mechanical part study or instructor-provided
Cutting Data Handbook	(For feeds, speeds, machining parameters)

IX. Precautions to be Followed

1. Ensure part dimensions and tolerances are verified before process planning.
2. Select the correct machine tool capability to avoid infeasible routing.
3. Choose standard cutting tools to minimize tool change and cost.
4. Verify feed & speed tables with material specifications.

X. Procedure

1. Open Kladana (Freeware) and log in.
2. Import / Upload part drawing.
3. Identify part features (e.g., cylindrical surface, hole, slot).

4. Select required manufacturing processes (turning, drilling, milling, etc.).
5. Choose a machine tool (Lathe / VMC / Drill Press).
6. Assign cutting tools (e.g., CNMG insert, Ø10 drill).
7. Enter feeds, speeds, and depth of cut**.**
8. Generate Routing Sheet (Operation Sequence) automatically.
9. Generate Tool Sheet (Tooling List)**.**
10. Export sheets to PDF for submission

XI. Observations and Identification Table (Routing Sheet)

No.	Machine	Operation	Tool	Cutting Parameters

XII. Results

XIII. Interpretation of Results

XIV. Conclusion and Recommendations

XV. Practical Related Questions

Note: Below given are a few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of the identified CO.

1) List the operation sequence used during the practical.
2) Name the machine tool selected.

[Space for Answer]

XVI. References / Further Reading

1) https://youtu.be/2dEG6gf254w
2) https://youtu.be/S5lhPGL9TIk
3) https://youtu.be/dOCfIyZzS7E
4) https://youtu.be/U6DWkAOkBP0

XVII. Rubrics for Assessment Scheme

Performance Indicator	Weightage
Process Related (15 Marks)	**(20%)**
Feature recognition & proper routing selection	10%
Selection of machine, tools, and parameters	10%
Product Related (10 Marks)	**(80%)**
Quality of Routing Sheet, Tool Sheet & Operation Sheet	40%
Justified interpretation of planning outcome	20%
Viva / Questions	20%
Total	**100%**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 05
*CNC code for a simple machining operation using a CNC Machine/Trainer/Simulator

I. Practical Significance

CNC programming translates engineering drawings into precise, repeatable machine motions. Mastery of G/M codes, coordinate systems, tool offsets, and safe start/end blocks is fundamental for productivity, quality, and operator safety in CIM environments. These practical builds hands-on competence using a Trainer/Simulator (Fanuc/Siemens style) before shop-floor execution.

II. Industry/Employer Expected Outcome(s)

Apply skills related to Computer-Integrated Manufacturing Systems in a real-world manufacturing environment.

III. Course Level Learning Outcomes (COs)

CO1 - Interpret the components of CIM architecture for a given application
CO2 - Apply CAD techniques to design simple mechanical parts
CO3 - Apply CAM techniques to optimize machining processes.

IV. Laboratory Learning Outcomes (LLOs)

LLO 5.1 Choose appropriate G and M codes for preparing part on CNC (Turning or Milling)
LLO 5.2 Develop a part with simple machining operations (like facing, turning, drilling, etc.) as per the given drawing

V. Relative Affective Domain Outcomes

- Handles CNC machine/simulator with responsibility and safety awareness.
- Maintains neat documentation of offsets, feeds, speeds, and dimensions.
- Demonstrate awareness of energy efficiency and sustainability.

VI. Minimum Theoretical Background

1. Coordinate systems: Machine zero vs. Work zero**;** G54–G59 work offsets.
2. Motion modes: G00 (rapid), G01 (linear feed), G02/G03 (CW/CCW arc).
3. Spindle modes (turning): G96 CSS, G97 RPM.
4. Canned cycles: G73/G83 (mill drilling), G81–G89 families; G74/G76 (turn threading).
5. Tool compensation: G41/G42 (cutter comp- milling), tool nose radius comp (G41/G42 in turning on some controls), G40 cancel.

Table: G and M Codes

Code	Meaning
G00	Rapid positioning
G01	Linear interpolation (feed)
G02/G03	CW/CCW arc
G17/G18/G19	Plane select XY/XZ/YZ (mills)
G40/G41/G42	Cutter comp cancel/left/right
G54–G59	Work offsets

G80–G89	Drilling cycles (mills)
G90/G91	Absolute / Incremental
G94/G95	Feed per minute / per rev
G96/G97	CSS on / RPM mode (lathes)
M03/M04/M05	Spindle CW/CCW/Stop
M06	Tool change (mills)
M08/M09	Coolant on/off
M30	Program end & rewind

VII. Experimental Setup

1. **Hardware:** CNC lathe (2-axis) or CNC vertical mill; or Trainer/PC Simulator.
2. **Controller:** Programme Controller
3. **Work material:** Mild steel bar Ø30 mm × 60 mm (protrusion ≈ 45 mm).
4. **Tools:** T01 Facing/OD (CNMG), T02 Drill Ø10 mm, T03 Chamfer tool (optional).
5. **Work holding:** 3-jaw chuck (turning) / machine vise (milling).
6. **Probing / Offsets:** Work offset G54; tool lengths/geometry set in offset table.

VIII. Required Resources

Category	Items
Software	Simulator (NCViewer/CIMCO/NCPlot) or machine control
Tooling	CNMG OD tool, Ø10 HSS/Carbide drill, deburr/chamfer
Measuring	Vernier caliper, steel rule
Documents	Drawing, process sheet, tooling sheet, this manual

IX. Precautions to be followed

1. Verify tool offsets before running feed moves
2. Always dry-run the above job before real cutting
3. Keep hand on feed-hold during first execution
4. Ensure program includes cancel codes G40, G80, G28/G30, M05

X. Procedure

1. Study the part drawing; choose a datum.
2. Select tools & enter geometry offsets.
3. Calculate spindle speed (N) and feed (f).
4. Write a CNC program in format.
5. Load into the simulator; troubleshoot alarms.
6. Dry run → Actual run.
7. Inspect final dimensions and record results.

Option A: Turning Operation (Lathe)

Drawing Objective: Turn the bar stock to the required diameter and drill a center hole.

```
O0101;
G21 G90 G40 G99;
T0101;
G54;
G96 S180 M03;
G00 X35 Z2;
G01 Z0 F0.25;
G01 X0 Z-20 F0.3;
G00 X50;
T0202;
G97 S1200 M03;
G00 X0 Z-10;
G01 Z-25 F0.2;
G00 X50 Z50;
M05;
M30;
```

Option B: Milling Operation (VMC)

Drawing Objective: Face top surface and mill a rectangular pocket.

```
O0201;
G21 G90 G17 G40;
T1 M06;
G54;
M03 S1200;
G00 X0 Y0 Z5;
G01 Z-1 F120;
G01 X50 Y0 F250;
G01 X50 Y40;
G01 X0 Y40;
G01 X0 Y0;
G00 Z10;
M05;
M30;
```

XI. Observation Table

Feature	Drawing Dimension	Measured Value	Tolerance	Accepted / Rejected
Outer Diameter / Slot Width				
Length / Pocket Depth				
Drilled Hole Diameter				

XII. Results

XIII. Interpretation of Results

XIV. Conclusion and Recommendations

XV. Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. State meaning and significance of G00 and G01
2. State meaning and significance of G90 and G91
3. Draw the structure of a part program.

[Space for Answer]

XVI. References / Further Reading

1. **https://youtu.be/YpQMUpWOgbE**
2. **https://youtu.be/ZgWYoFWTKJc**
3. **https://youtu.be/al1JIqp648s**

XVII. Rubrics for Assessment Scheme

Performance Indicator	**Weightage**
Process Related (15 Marks)	**(20%)**
Program syntax correctness, safe start/end blocks	10%
Simulator operation, dry-run & error correction discipline	10%
Product Related (10 Marks)	**(80 %)**
Accuracy of machined output / simulated path	40%
Report interpretation & tool wear compensation understanding	20%
Viva / Questions	20%
Total	**100%**

Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 06
Inspection of the Machined Part Using Available CAQC Software

I. Practical Significance

Quality inspection ensures that manufactured components meet their dimensional, tolerance, and surface finish requirements. Using CAQC software helps eliminate manual measurement errors, reduces inspection time, and supports closed-loop machining optimization.

II. Industry/Employer Expected Outcome(s)

Apply skills related to Computer-Integrated Manufacturing Systems in a real-world manufacturing environment

III. Course Level Learning Outcomes (COs)

CO3 - Apply CAM techniques to optimize machining processes.

IV. Laboratory Learning Outcomes (LLOs)

LLO 6.1 Inspect the dimensional accuracy of the component using available CAQC software

V. Relative Affective Domain Outcomes

- Uses licensed/authorized software responsibly.
- The student values the importance of accurate measurement and tolerance verification using CAQC tools.
- Applies inspection feedback constructively to correct machining variations.

VI. Minimum Theoretical Background

CAQC (Computer Aided Quality Control): CAQC uses software integrated with metrology systems to automatically inspect part features against CAD models and GD&T specifications.

Term	Meaning
Nominal	Ideal dimension from CAD/drawing
Actual	Measured value
Tolerance	Allowed variation in size/shape
Error / Deviation	Actual − Nominal
GD&T	Defines geometric accuracy (flatness, perpendicularity, position, etc.)

A coordinate-measuring machine (CMM) is a device that measures the geometry of physical objects by sensing discrete points on the surface of the object with a probe. Following table shows general CMM specifications.

Specification	Value
Measuring Range	300 mm × 300 mm × 200 mm
Accuracy	± (3.0 + L/250) µm
Probe Type	Touch Trigger Probe
Software	Licensed CAQC Software

CAD Model / Drawing

↓

Machined Component

↓

CMM / Scanner / Digital Probe

↓

CAQC Software (Measurement, Deviation Analysis)

↓

Determine Fixture & Clamping Methods

↓

Generating Routing and Operation Sheets

Figure: Inspection Workflow Diagram

VII. Experimental Set Up

1. Licensed Software: PC-DMIS / MCOSMOS / CMM-Manager / Verisurf / PolyWorks (any available)
2. Hardware: CMM or 3D Scanner / Probe System
3. Workpiece: Part machined
4. Input Data: Engineering drawing with GD&T symbols

VIII. Required Resources:

Resource Type	Items Required
Hardware	CMM / Probe / Scanner, Fixture clamp
Licensed Software	CAQC / CMM control software
Measuring Aids	Gauge blocks, calibration sphere
Documents	Engineering drawing of part

IX. Precautions to be Followed

1. Calibrate the CMM before measurement.
2. Keep the part clean, burr-free, and at a stable room temperature.
3. Avoid direct handling to prevent thermal expansion.
4. Align the part properly to datum A-B-C before measurement.
5. Use a gentle probe contact to avoid stylus deflection

X. Procedure

1. Place and secure the part on the inspection table.
2. Launch the CAQC software and load the CAD model or drawing.
3. Set datum system (A, B, C) according to the GD&T frame.
4. Perform probing of required features (diameters, lengths, angles).
5. Software computes actual versus nominal dimensions.
6. Review tolerance and deviation results.
7. Generate inspection report (pass/fail status).

8. Use deviation feedback to adjust machining tool wear or process parameters

XI. Observation Table

Feature Measured	Nominal (mm)	Actual (mm)	Tolerance	Deviation	Result

XII. Results

XIII. Interpretation of Results

XIV. Conclusion and Recommendations

XV. Practical Related Questions

Note: Below are a few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of the identified CO.

1. State the purpose of CAQC in manufacturing

2. Justify the selection of the datum surface on the workpiece during practical performance.

[Space for Answer]

XVI. References / Further Reading

1) *https://www.youtube.com/watch?v=xGXGFTrCJVc*
2) https://youtu.be/AqtDNE9SCWQ
3) https://youtu.be/G7wnGeR_69k

XVII. Rubrics for Assessment Scheme

Performance Indicator	Weightage
Process Related (15 Marks)	**(20%)**
Proper datum setup & probing procedure	10%
Clean handling & calibration care	10%
Product Related (10 Marks)	**(80%)**
Accuracy of inspection report & tolerance reading	40%
Interpretation & correction suggestion	20%
Viva / Questions	20%
Total	**100%**

Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 07
MRP (Material Resource Planning) software for CIM and assembly

I. Practical Significance

MRP ensures the availability of materials and components at the correct time and quantity, minimizing inventory cost and preventing production delays. In CIM environments, MRP integrates BOM data, inventory records, and production schedules, enabling automated planning and real-time decision-making.

II. Industry/Employer Expected Outcome(s)

Apply skills related to Computer-Integrated Manufacturing Systems in a real-world manufacturing environment

III. Course Level Learning Outcomes (COs)

CO1 - Interpret the components of CIM architecture for a given application
CO3 - Apply CAM techniques to optimize machining processes.
CO4 - Use different software and hardware in CIM efficiently.

IV. Laboratory Learning Outcomes (LLOs)

LLO 7.1 Select a suitable MRP software for CIM and assembly.
LLO 7.2 Prepare report on the real-time data obtained by MRP Software in automated manufacturing

V. Relative Affective Domain Outcomes

- Demonstrates professional responsibility in data entry and planning decisions.
- Shows awareness of the importance of avoiding overstock/shortage.

VI. Minimum Theoretical Background

Material Resource Planning (MRP) is a computerized planning system used in manufacturing to ensure that the right materials are available at the right time in the right quantity. It calculates material requirements based on production schedule, Bill of Materials (BOM), and current inventory.

Input	Description
Master Production Schedule (MPS)	Defines *what* and *when* to produce
Bill of Materials (BOM)	Lists components required for assembly
Inventory Status	Available stock and work-in-progress levels

MRP Output: What, How, and when to order?
Purpose of MRP: Prevent material shortages, reduce excess inventory cost, ensure smooth and continuous production

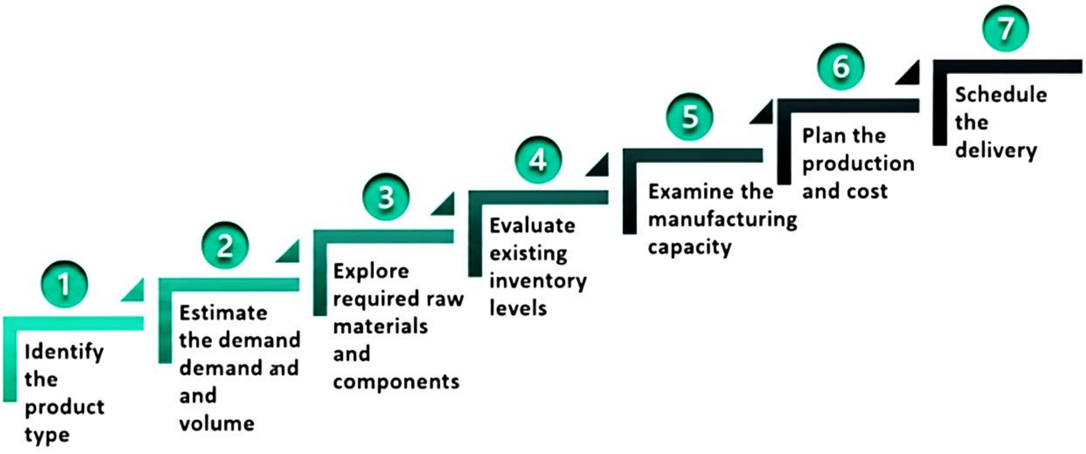


Fig 7.1: Steps in Material Resource Planning

VII. Experimental Set Up

Component	**Specification**
Software	MRP (Licensed/Educational Edition)
Inputs Required	BOM, MPS, Inventory Values
Output	Material Requirement Plan Report

VIII. Required Resources:

1. Computer with installed MRP software
2. Sample product BOM
3. Inventory data sheet

IX. Precautions to be Followed

1. Ensure accurate BOM entry (incorrect BOM gives incorrect plan)
2. Verify stock levels before executing the planning run
3. Use correct lead time and procurement durations

X. Procedure

1. Open software → Manufacturing → MRP Module.
2. Create / Load Product BOM.
3. Enter Master Production Schedule (Quantity & Date).
4. Check on-hand inventory in stock.
5. Click Run MRP / Material Planning.
6. Software generates:
7. Quantity required
8. Reorder / Purchase proposals
9. Work orders (if in-house manufacturing)
10. Generate & save MRP Report (PDF/Excel).

XI. Observation Table

Step	Input / Output Recorded	Software Output / Interpretation/ Remarks
BOM Entered	Components List	
MPS Entered	Production Schedule	
Inventory Status	Stock Levels	
MRP Run Output	Required Materials	___ units required
Planned Order Dates	System Calculation	Lead Time = ___ Days
Final Recommendation	Procurement / Production Decision	

XII. Results

XIII. Interpretation of Results

XIV. Conclusion and Recommendations

XV. Practical Related Questions

Note: Below are a few sample questions for reference. Teachers must design more such questions to ensure the achievement of the identified CO.

1. Justify the statement Material shortage issue is precisely solved by MRP
2. Differentiate between BOM and Inventory Record

[Space for Answer]

XVI. References / Further Reading

1) https://youtu.be/Nra6KSNorg4
2) https://youtu.be/6Ct6r5ZqCek
3) https://youtu.be/jdKmQWdjSDI
4) https://youtu.be/vmk3yzQArpo
5) https://youtu.be/AYO_QGhRHdA

XVII. Rubrics for Assessment Scheme

Performance Indicator	Weightage
Process Related (15 Marks)	**(20%)**
Correct entry of BOM, MPS, and Inventory data	10%
Logical selection & justification of software	10%
Product Related (10 Marks)	**(80 %)**
Accuracy of MRP Plan & Report Interpretation	40%
Conclusion based on data output	20%
Answering viva/practical questions	20%
Total	**100%**

Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 8

Layout of network topology and network hardware/network software for given situation.

I. Practical Significance

Networking in CIM allows data sharing between design, planning, and manufacturing departments through computer networks. This practical demonstrates how different network topologies and related hardware/software are used to establish reliable data exchange systems in manufacturing industries. Student should be able to connect computers of laboratory in various topology using transmission media and network control devices.

II. Industry/Employer Expected Outcome(s)

Apply skills related to Computer-Integrated Manufacturing Systems in real-world manufacturing environment.

III. Course Level Learning Outcome(s) (CO)

CO4 - Use different software and hardware in CIM efficiently.

IV. Laboratory Learning Outcome(s)

LLO 8.1 - Prepare a layout using suitable network topology in given situation.

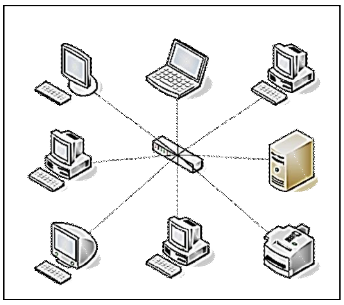
LLO 8.2 - Connect given computer systems/hardware as per network layout.

V. Relative Affective Domain related Outcome(s)

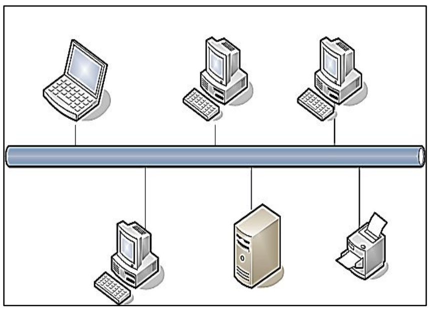
- Carefully handle computer and networking equipment.
- Explore networking applications used in CIM.

VI. Minimum Theoretical Background with diagram (if required)

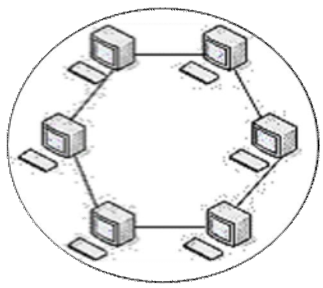
Network Topology refers to layout of a network. How different nodes in a network are connected to each other and how they communicate is determined by the network's topology. In CIM, different types of network topologies are used to interconnect systems for data transfer and control



Star Topology



Bus Topology



Star Topology

1. **Star Topology:** All nodes are connected to a central hub or switch. It provides reliability and easy maintenance.
2. **Bus Topology:** All computers share a single communication line. It is economical but prone to data collision.
3. **Ring Topology:** Each node is connected to two others, forming a ring. Data travels in one direction, reducing collision.

VII. Experimental setup

A well setup computer network laboratory of computers, switches, routers, cables, and CIM-related software is arranged according to the chosen network topology layout. Each node represents a functional area such as CAD, CAM, and Production Control.

VIII. Required Resources/Apparatus/Equipment with specification [Table format]

1. Computers (Minimum 4GB RAM, LAN Card Installed)
2. Switches/Hub – 8 Ports or 16 Port Ethernet Switch
3. CAT6 Ethernet Cables – Appropriate Length
4. RJ45 Connectors, Crimping Tool.

IX. Precautions to be followed

1. Ensure power supply is turned off before connecting cables.
2. Avoid excessive bending of network cables.
3. Use correct IP addressing and subnet settings.
4. Verify proper driver installation for network adapters.
5. Keep all software licensed/ open source for academic use only.

X. Procedure

1. Identify the network topology suitable for the identified laboratory in the institute.
2. Arrange computers and network devices as per selected topology (Star/Bus/Ring).
3. Connect all systems using CAT6 cables.
4. Configure IP addresses and subnet masks for all systems.
5. Test the network connectivity using ping command.
6. Observe data transfer between different computers.
7. Draw the network layout of laboratory using CAD software.

XI. Observations

Record the following parameters:

1. IP Address and topology in of each observed laboratory.
2. Data transfer rate observed.

XII. Results:

Sr. No.	IP Adress	Location	Type of Topology observed
1			
2			
3			
4			
5			

XIII. Interpretation of Results

XIV. Conclusions and Recommendations

XV. Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

i. Identify Network topology used in given laboratory.

ii. Evaluate the suitability of the network topology implemented in your laboratory setup

iii. Name different connectors and cables used in this practical with specifications.

[Space for Answer]

XVI. References / Suggestions for Further Reading

1) https://www.ibm.com/think/topics/network-topology
2) https://youtu.be/zbqrNg4C98U?si=CxZMlTJ-1VCMzBKY
3) https://youtu.be/lEmBNqoBpZU?si=xz-KSgqoFhheniYB

XVII. Rubrics for Assessment Scheme

	Performance Indicators	**Weightage**
	Process Related (15 Marks)	**(60%)**
1.	Prepare a layout using suitable network topology in given situation.	30%
2.	Identify network topology available in computer laboratory.	30%
	Product Related (10 Marks)	**(40%)**
3.	Interpretation of result.	20%
4.	Rubrics related questions.	20%
	Total	**100%**

Marks Obtained			**Dated signature of Teacher**
Process Related(15)	**Product Related (10)**	**Total (25)**	

Practical No. 9

Design simple manufacturing cells (e.g., Machining Cell, Assembly Cell) using available CAD Software

I. Practical Significance

Understanding and designing simple manufacturing cells helps in improving production efficiency, reducing lead time, and enhancing flexibility in manufacturing systems. Students will gain hands-on experience in designing and visualizing machining and assembly cells using CAD software.

II. Industry/Employer Expected Outcome(s)

Apply skills related to Computer-Integrated Manufacturing Systems in real-world manufacturing environment.

III. Course Level Learning Outcome(s) (CO)

CO1: Interpret components of CIM architecture for a given application.
CO2: Apply CAD techniques to design simple mechanical parts.
CO3: Apply CAM techniques to optimize machining processes.
CO5: Develop programs to manage robotic/automation systems using relevant software.

IV. Laboratory Learning Outcome(s)

LLO 9.1: Simulate system components such as conveyors, machining centers, and assembly lines using available software.

V. Relative Affective Domain related Outcome(s)

- Work effectively in a team.
- Follow laboratory safety and ethical practices.
- Maintain proper documentation and file organization.

VI. Minimum Theoretical Background with diagram

A machining cell is a group of machines arranged in close proximity to perform a series of machining operations on a part. These cells can be manual or automated, often using robotic arm to load and unload machines, and are designed to improve efficiency by reducing the distance parts travel between operations and streamlining the production process.

Types of Machining Cells:

1) **Single Machine Cell:** One CNC machine performing multiple operations. Example: CNC machining center performing turning, milling, and drilling on one setup.

2) **Group of Machine Tools Cell:** Two or more machines arranged in sequence for part family manufacturing. Example: Turning → Milling → Drilling sequence for automotive components.

3) **Flexible Machining Cell (FMC):** A computer-controlled cell consisting of 2–3 CNC machines, automated material handling, and a central control computer. It enables unattended or lightly attended operations.

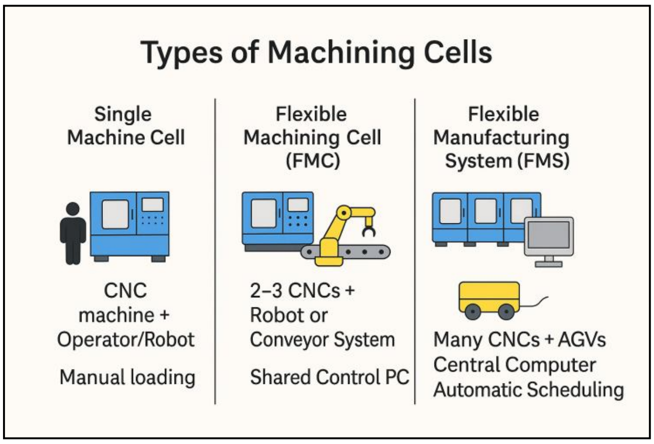


Fig. 9.1 Types of Machining Cells

VII. Experimental setup

Fig. 9.2 Actual photograph of Polytechnic Workshop

VIII. Required Resources/Apparatus/Equipment with specification [table]

1. Computer (min. 4 GB RAM, 500 GB HDD).
2. CAD software (e.g., AutoCAD).
3. Specification and overall dimensions of machine.
4. Measuring tools (measuring tape, laser measuring tool (EDM)) for reference layout measurement.

IX. Precautions to be followed

1. During the measurement all machines should be switched off.
2. Proper safe distance from Machine cell.
3. Use proper PPE kit while working in workshop

X. Procedure

1. Identify type of manufacturing cell.
2. Measure the dimensions of each machines and manufacturing cell.
3. Prepare CAD layout using CAD software.
4. Plot the layout.

XI. Observations

1) Record dimensions of each machine and distance between stations.

XII. Results

XIII. Interpretation of Results

XIV. Conclusions and Recommendation

XV. Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified Course Outcome (CO).

1. Name the manufacturing cell under observation, justify.
2. List components of a machining cell.
3. Draw three layouts of manufacturing cells.

[Space for Answer]

XVI. References / Suggestions for Further Reading

1) https://youtu.be/gZtoYfSo0yM?si=a-kPWCHpjzWHxMtO
2) https://youtu.be/l6B5WtjaCx0?si=FJgLLPDYDjCaE4uO
3) https://invioautomation.com/capabilities/assembly-cells/

XVII. Rubrics for Assessment Scheme

Performance Indicators		Weightage
Process Related(15Marks)		**(60%)**
1.	Understanding of manufacturing cell design objectives	30%
2.	Able to design simple manufacturing cell in Available CAD Software	30%
Product Related(10Marks)		**(40%)**
3.	Interpretation of result.	20%
4.	Practical related questions.	20%
	Total	**100%**

Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 10

*PLC Programming to control a simple automation system.

I. Practical Significance

Students will learn the fundamentals of PLC programming, ladder logic design, and control of basic automation systems such as conveyor movement, light control, or actuator-based processes.

II. Industry/Employer Expected Outcome(s)

Apply automation, robotics, and networking principles in manufacturing to enhance productivity and integration.

III. Course Level Learning Outcome(s) (CO)

CO5 - Develop programs to manage robotic/automation systems using relevant software.

IV. Laboratory Learning Outcome(s)

LLO 10.1Write a simple Ladder Logic program for simple applications.
LLO 10.2 Program for simple automation applications.

V. Relative Affective Domain related Outcome(s)

- Work effectively in a team.
- Follow safety and ethical laboratory practices.
- Maintain accurate documentation of experiments.

VI. Minimum Theoretical Background with diagram (if required)

Before performing this practical, students should possess foundational knowledge of Programmable Logic Controllers (PLCs) and its function. A PLC is a compact industrial computer designed to control various processes and systems. It receives input signals from sensors or switches, processes them based on the programmed logic, and sends control commands through its output modules to operate actuators or devices. Essentially, a PLC automates system operations according to the logic programmed within it.

VII. Experimental setup

Fig 10.1 A photograph of PLC

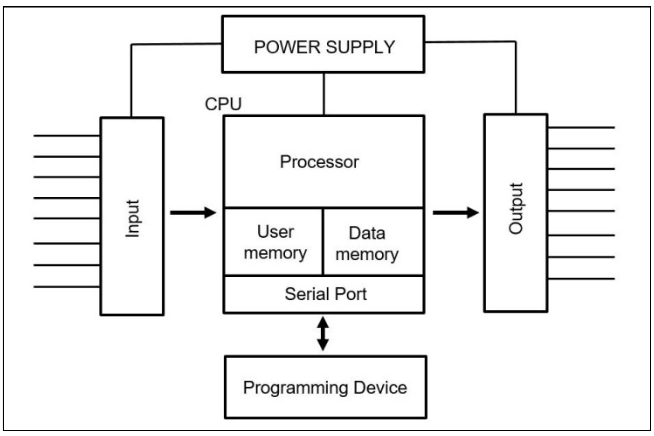


Fig 10.2 Block diagram of a PLC

VIII. Required Resources/Apparatus/Equipment with specification

Computer system with CAD/CAM/PLC/Robot Simulation software
PLC Trainer Kit

IX. Precautions to be followed

Ensure correct wiring or virtual configuration.
Double-check logic/program before execution
Avoid improper handling of instrument.
Maintain safe distance from operating equipment.
Save work frequently.
Follow safety practices about maintaining tools and equipment.

X. Procedure

Select one of the simple automation systems. (e.g. 1. conveyor on/ off, 2. Servomotor on/ off, 3. Stepper Motor On/ off or any other related to simple automation system. etc.)
Write ladder program for selected simple automation system.
Develop logic/program/model as per requirement.
Simulate or execute the program.
Record results and observations.

XI. Observations

Sr. No.	Name of automation system	Ladder Logic Developed Yes/No	Timing Recorded for automaton
1	Conveyor on/ off		
2	Servomotor on/ off		
3	Stepper Motor On/ off		
4	Any other related to simple automation system		

Ladder Logic diagram of listed automation systems.

XII. Results

XIII. Interpretation of Results

XIV. Conclusions and Recommendation

XV. Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified Course Outcome (CO).

1. List various automation systems available in laboratory.
2. Name different PLC controllers.

[Space for Answer]

XVI. References / Suggestions for Further Reading

1) https://basicplc.com/plc-programming/
2) https://inductiveautomation.com/resources/article/what-is-a-PLC
3) https://youtu.be/GhgFdLDdUIY?si=fEfKLj2C7oF2abTT
4) https://youtu.be/51hELJPg4kU?si=EaZ7g81p7mWIkXxK

XVII. Rubrics for Assessment Scheme

Performance Indicators		Weightage
Process Related(15Marks)		**(60%)**
1.	Write ladder logic diagram for given automation system	30%
2.	Observe control system of given automation system using PLC programming.	30%
Product Related(10Marks)		**(40%)**
3.	Interpretation of result.	20%
5.	Practical related questions.	20%
	Total	**100%**

Marks Obtained			Dated signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 11

Programming of a robot to perform simple task.

I. Practical Significance

This practical focuses on programming a robot for simple movements using motor control commands to execute linear and angular motions like pick, move, and place. Students will also able to select the required hardware components for the simple task.

II. Industry/Employer Expected Outcome(s)

Apply skills related to Computer-Integrated Manufacturing Systems in real-world manufacturing environment.

III. Course Level Learning Outcome(s) (CO)

CO5 - Develop programs to manage robotic/automation systems using relevant software.

IV. Laboratory Learning Outcome(s)

LLO 11.1 Select the required hardware components (motors, sensors, Prime controllers) and their functions.

LLO 11.2 Program for the simple robot with wrist or arm movements (to move forward, backward, turn and stop) using motor control commands.

V. Relative Affective Domain related Outcome(s)

- Work effectively in a team.
- Follow safety and ethical laboratory practices.
- Maintain accurate documentation of experiments.

VI. Minimum Theoretical Background

A robot is a programmable mechanical device capable of performing tasks automatically with high accuracy and repeatability. In industrial applications, robots are programmed to carry out operations such as pick-and-place, welding, painting, assembly, and material handling. Robot programming provides the set of instructions that define how a robot moves, interacts with objects, and executes a sequence of actions. It ensures that the robot performs the intended task safely, efficiently, and repeatedly under defined conditions.

VII. Experimental setup

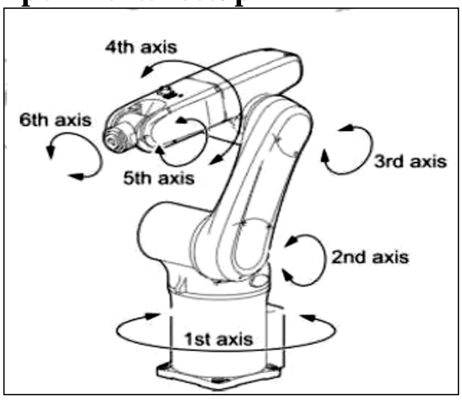


Fig 11.1 6 DoF Articulated

Fig 11.2 SCARA Robot

VIII. Required Resources/Apparatus/Equipment with specification

Sr. No.	Name of resources	Suggested broad specification	Quantity
1	Robotic Arm	Working model with suitable dimensions	01
2	Controller	Working Model	01
3	Teach Pendent	Working Model	01
4	End effectors	Working Model	01
5	Hardware components of robots. e.g. Motor, Sensors and Prime Controllers	Specification of components	01

IX. Precautions to be followed

1) Ensure correct wiring or virtual configuration.
2) Double-check logic/program before execution.
3) Maintain safe distance from operating equipment.
4) Ensure the robot's workspace is clear of obstacles and personnel.
5) Always run programs in "teach" or slow mode during initial testing.
6) Verify end-effector alignment with work piece before gripping.
7) Avoid manual intervention when the robot is in automatic cycle mode.
8) Keep emergency stop switches active and accessible.

X. Procedure

1) Turn on robotic setup.
2) Select world coordinate system on teach pendent.
3) Move End-of-arm tooling (EOAT) to any point using X and Y direction.
4) Record point and note down X and Y coordinates.
5) Repeat procedure number 3 and record new point.
6) Record at least four distinct points.
7) Run recorded program

XI. Observations

A) List of Hardware components

Sr. No.	Name of components	Manufacturer	Specification of components	Functions of components
1	DC Motor/ Servo Motor			
2	First Sensor			
3	Second Sensors			
4	Third Sensor			
5	Fourth Sensor			
6	Prime Controller (Arduino Uno / Raspberry Pi / PLC controller)			

B) Readings on Robot setup

Sr. No.	Movements	Commands	Position	X Coordinate	Y Coordinate	Z Coordinate
1.	**Start**	--	Initial position			
2.	**Wrist of robot**	Move Forward	Initial position			
			Final position			
		Move Backward	Initial position			
			Final position			
3.	**Turning of wrist**	Clockwise turning	Initial position			
			Final position			
		Counter clockwise turning	Initial position			
			Final position			
4.	**Turning of arm**	Clockwise turning	Initial position			
			Final position			
		Counter clockwise turning	Initial position			
			Final position			
5.	**Stop**	--	Final position			

XII. Results

XIII. Interpretation of Results

XIV. Conclusions and Recommendation

XV. Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified Course Outcome (CO).

1) Explain different configuration of industrial robots.
2) List software used for robotic simulation.
3) Explain various coordinate system used in industrial robotics.

[Space for Answer]

XVI. References / Suggestions for Further Reading

1) https://youtu.be/rYWJdZ5qg6M?si=0Gv4L6_tiFOTeAn4
2) https://youtu.be/RmxjVp_tXgI?si=sXsdofUI0IWA_uW_
3) https://youtu.be/kjZVi8x-m0E?si=CVvp6dRuWVSnnHn5
4) Free Robot programming software's
   a. https://www.igus.in/automation/robot-control-system/robot-software#%20roboter-software%20downloaden
   b. https://robodk.com/download
5) https://in.mathworks.com/discovery/robot-programming.html

XVII. Rubrics for Assessment Scheme

Performance Indicators		Weightage
Process Related(15Marks)		**(60%)**
1.	Selection of the required hardware components for robots	30%
2.	Program the simple robot with wrist or arm movements.	30%
Product Related(10Marks)		**(40%)**
3.	Interpretation of result.	20%
4.	Rubrics related questions.	20%
	Total	**100%**

Marks Obtained			Dated signature of Teacher
Process Related(15)	**Product Related(10)**	**Total(25)**	

Practical No. 12

*Use Teach Pendent/Offline Programming/Simulation Software to program a robotic arm to perform pick and place and stacking of objects.

I. Practical Significance

Performing a pick and place application practical allows students to apply robotics concepts in a real-world scenario. It develops skills in programming, tool control, and motion planning. Students learn how to interface and calibrate end effectors, handle objects accurately, and ensure system safety. This practical enhances problem-solving, teamwork, and prepares students for automation roles in industries like manufacturing and logistics.

II. Industry/Employer Expected Outcome(s)

Apply skills related to Computer-Integrated Manufacturing Systems in real-world manufacturing environment.

III. Course Level Learning Outcome(s) (CO)

CO1 - Interpret the components of CIM architecture for a given application.

CO5 - Develop program to manage robotic/automation system using relevant software.

IV. Laboratory Learning Outcome(s)

LLO 12.1 Prepare a robot program to perform simple tasks by using available Teach Pendant/Offline Programming/Simulation Software.

V. Relative Affective Domain related Outcome(s)

- Follow safety practices.
- Demonstrate working as a leader/a team member.
- Maintain tools and equipment.
- Follow ethical Practices.

VI. Minimum Theoretical Background with diagram (if required)

Before performing this practical student must have knowledge of Industrial robot components and its functions, Coordinate systems in industrial robotics, Interpolation motions in robotics, End effectors commands, Programming industrial robot.

When programming a robot for pick-and-place or stacking operations, the teach pendant is the primary interface for defining how the robot:

1) Moves between pick and place points,
2) Controls the gripper (open/close), and
3) Sequences these actions in the correct order.

A Teach Pendant is a handheld device used to manually program and control a robotic arm for performing operations such as pick and place and stacking of objects. It allows the operator to move the robot to specific positions using jog keys or joysticks and then record these positions as part of a sequence. In a typical pick-and-place application, the teach pendant is used to guide the robot to the pick-up location, activate the gripper to hold the object, move it to the desired place position, and then release it.

VII. Experimental setup (Model)

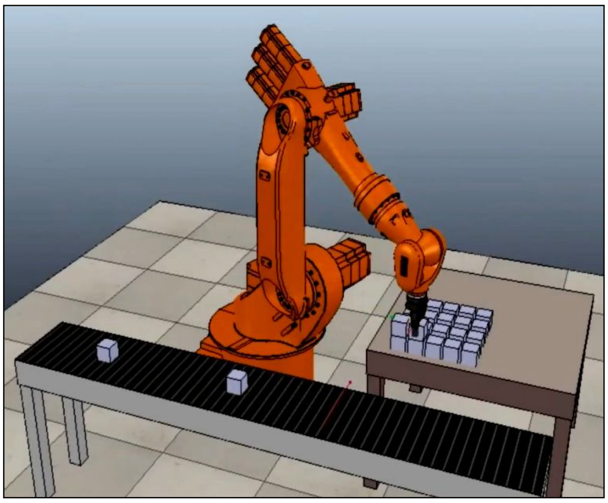


Fig. 12.1 Pick and place application using 6 DOF robot

A 6-DOF industrial robot (arm with 6 revolute joints) is ideal for flexible pick-and-place because it can reach arbitrary orientations within its workspace. Typical use: pick part from conveyor/bin → orient part → place at target (assembly, pallet, and packaging). Key success factors: correct end-effector, reliable part detection (vision/sensors), and smooth motion planning.

VIII. Required Resources/Apparatus/Equipment with specification

Sr. No.	Name of resources	Suggested broad specification	Quantity
1	Robotic Arm	Working model with suitable dimensions	01
2	Controller	Working Model	01
3	Teach Pendent	Working Model	01
4	End effectors	Working Model	01

IX. Precautions to be followed

1) Perform practical under observation of instructor.
2) Don’t move EOAT very close to table or object.

X. Procedure

1) Turn of robotic setup.
2) Create new program.
3) Move EOAT (End of Arm Tooling) to desirable point (home location) and record point.
4) Select suitable end effectors
5) Move EOAT at point above pick up location and record point.
6) Move EOAT down to pick object and record point.
7) Close gripper.
8) Move EOAT upward record point.
9) Move EOAT at point above drop location and record point.
10) Move EOAT down and record point.
11) Open gripper.
12) Move EOAT upward and record point.
13) Move EOAT to 1st point (Home location)
14) Use JUMP command to repeat program.
15) Write down this in observation table below

XI. Observations

Line Number	Command	Comment
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		

XII. Results

XIII. Interpretation of Results

XIV. Conclusions and Recommendation

XV. Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified Course Outcome (CO).

1) Develop a program for Bolt inspection task.
2) Develop a program for assembly of bolt and washer.

[Space for Answer]

XVI. References / Suggestions for Further Reading

1) https://www.youtube.com/watch?v=CVoV08T0Aqo
2) https://youtu.be/TuZVYcTgXQs?si=z5KCzZVqlUVBq0_O
3) https://robodk.com/blog/industrial-robot-programming/

XVII. Rubrics for Assessment Scheme

Performance Indicators		Weightage
Process Related(15Marks)		**(60%)**
1.	Handling of the set up	30%
2.	Observations of set up	30%
Product Related(10Marks)		**(40%)**
3.	Interpretation of result.	20%
4.	Rubrics related questions.	20%
	Total	**100%**

Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 13

Elements of FMS and its nature of controlling by computer through Video film/actual demonstration (plant visit).

I. Practical Significance

Students will understand the concept of Flexible Manufacturing Systems (FMS) and their computer-controlled automation through plant visits or video demonstrations.

II. Industry/Employer Expected Outcome(s)

Apply skills related to Computer-Integrated Manufacturing Systems in real-world manufacturing environment.

III. Course Level Learning Outcome(s) (CO)

CO3 - Apply CAM techniques to optimize machining processes.

CO5 - Develop program to manage robotic / automation system using relevant software.

IV. Laboratory Learning Outcome(s)

LLO 13.1 Prepare a detailed report on the elements of an FMS and its computer-controlled automation.

LLO 13.2 Arrange a presentation in a group on FMS technology in modern smart factories.

V. Relative Affective Domain related Outcome(s)

- Work effectively in a team.
- Follow safety and ethical laboratory practices.
- Maintain accurate documentation of experiments.
- Prepare report on presentation.

VI. Minimum Theoretical Background with diagram (if required)

A Flexible Manufacturing System (FMS) is a manufacturing system in which there is some amount of flexibility that allows the system to react in case of changes, whether predicted or unpredicted. FMS relies on automation as much as possible using advanced technology and flexible manufacturing software, resulting in higher overall quality and productivity, lower costs, and less waste.

Elements of FMS

1) Workstations
2) Material handling and Storage system
3) Computer System
4) Manager and Operator

VII. Experimental setup

For this practical the faculty can perform any one of the following options to write the detail report on FMS practical.

1) Visit nearby plant visit (industry visit) which uses Flexible Manufacturing System.
2) Observe the links of Video film given here to understand the Flexible Manufacturing System.

a. https://youtu.be/FAitPrV0UsY?si=VIUyBThbFbRDMuQo

b. https://youtu.be/cUzbkfK6pUA?si=KakmGaysvc3xe-sh

VIII. Required Resources/Apparatus/Equipment with specification [Table format]

1) Computer system with internet connection
2) Speakers for listening audio from the FMS film

IX. Precautions to be followed

1) Students must follow following precautions during plant visit for FMS
   a. Follow safety precautions given by the industry officials.
   b. Wear proper college uniform and safety shoes.
   c. Don't touch any instruments or machine in Industry premises without prior permission from authority
   d. Observer discipline during entire visit and walking in Industry.
2) Follow safety instructions given by the subject teacher.

X. Maintain safe distance from operating equipment.

Procedure:

1) Record the observation from the plant visit
2) Observe the video film regarding FMS.
3) Prepare group of 3 to 4 students for the presentation on FMS topic.
4) Each group will present the selected topic for 5 minutes with minimum 10 slides.

XI. Observations:

Part A):

Name of Industry Visited:

____

Address of the Industry:

____

Sr. No.	FMS Elements	Functions of elements	Use of elements in Industry you visited
1	Workstations		
2	Material handling and Storage system		
3	Computer System		
4	Manager and Operator		

Part B): Presentation in a group on FMS technology in modern smart factories.

Name of topic selected for presentation:

____

Name of group members:

1) …………………………………………….
2) …………………………………………….
3) …………………………………………….
4) …………………………………………….

XII. Results:

Learning from FMS Video film or Plant Visit: --

Learning from FMS Presentation: --

XIII. Interpretation of Results

XIV. Conclusions and Recommendations

XV. Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified Course Outcome (CO).

1) Mention benefits of FMS.
2) Explain Material handling and Storage system used in FMS.
3) Explain FMS elements interconnected and computer-controlled in a smart-factory environment through the given video link.

[Space for Answer]

XVI. References / Suggestions for Further Reading

1) https://www.autodesk.com/solutions/flexible-manufacturing-system
2) https://www.unleashedsoftware.com/blog/flexible-manufacturing-in-2021-flexible-manufacturing-systems-explained/
3) https://youtu.be/6AW8xUTRVpg?si=BIxUztol_qdXN8zb
4) https://youtu.be/IHCQccvs3tM?si=eJ4ig7u7qyUpcE7S

XVII. Rubrics for Assessment Scheme

	Performance Indicators	**Weightage**
	Process Related(15Marks)	**(60%)**
1.	Understanding and Observation of FMS Elements	30%
2.	Participation, Teamwork, and Application of Knowledge in Presentation	30%
	Product Related(10Marks)	**(40%)**
3.	Interpretation of result.	20%
4.	Rubrics related questions.	20%
	Total	**100%**

Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 14
Various elements of Robotic Systems, types of robots, their configuration, and the nature of controlling by computer through video/actual demonstration (plant visit)

I. Practical Significance

This practical focuses on fundamental elements of robotic systems, types of robots with configuration and their nature of control by a computer

II. Industry/Employer Expected Outcome(s)

Apply skills related to Computer-Integrated Manufacturing Systems in a real-world manufacturing environment.

III. Course Level Learning Outcome(s) (CO)

CO4 - Use different software and hardware in CIM efficiently.

CO5 - Develop programs to manage robotic/automation systems using relevant software.

IV. Laboratory Learning Outcome(s)

LLO 14.1 Prepare a detailed report on robotic elements, type, configuration, and control mechanisms.

LLO 14.2 Arrange a presentation in a group on findings of robotics trends in Industry 4.0 and Smart Manufacturing.

V. Relative Affective Domain related Outcome(s)

- Work effectively in a team.
- Follow safety and ethical laboratory practices.
- Maintain accurate documentation of experiments.
- Prepare a report on the presentation.

VI. Minimum Theoretical Background with diagram (if required)

A robotic system is a programmable, multifunctional mechanical device designed to perform tasks through computer control and mechanical actuation. It consists of several integrated elements that work together to execute automated operations with precision and repeatability.

1) Manipulator
2) Robot Arm
3) Drive System
4) End Effector (Gripper or Tool)
5) Sensors
6) Computer for Control
7) Power Supply
8) Programming and Control Software

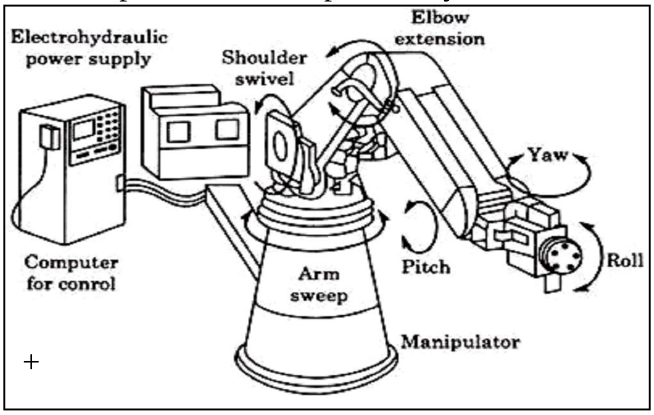


Fig 14.1 Components of Robotic System

A control mechanism in a robot governs how motion commands are generated, executed, and adjusted based on feedback. It ensures that the robot's joints, actuators, and end-effectors perform the desired task with accuracy, repeatability, and stability. Robotic control systems are broadly categorized into open-loop and closed-loop (feedback) control mechanisms.

VII. Experimental setup

For this practical the faculty can perform any one of the following options to write the detail report on Robotic Systems practical.

1) Visit nearby manufacturing plant (industry visit) which uses Robotic Systems
2) Observe the links of Video film given here to understand the Robotic Systems

a. https://youtu.be/_canCYWZPsc?si=aoQNZqigCsfYAL5i
b. https://youtu.be/Cndodc3X50s?si=NF-wzZbjZnCEQfTb
c. https://youtu.be/s-yne8xTNM0?si=qmrahmkvb0PF990F

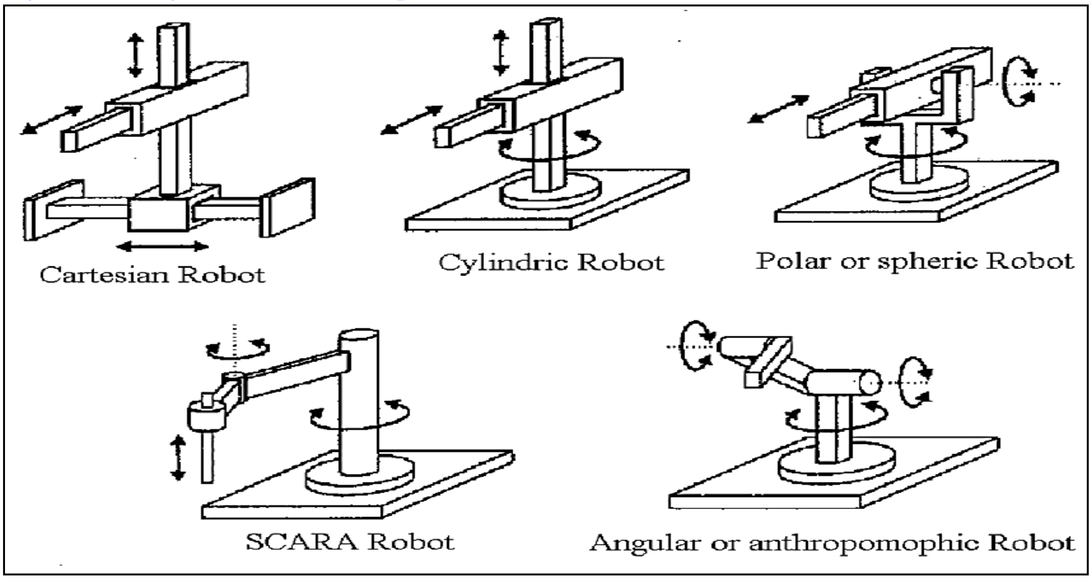


Fig 14.2 Types of Robot Systems

VIII. Required Resources/Apparatus/Equipment with specification

Sr. No.	Name of resources	Suggested broad specification	Quantity
1	Robotic Arm	Working model with suitable dimensions	01
2	Controller	Working Model	01
3	Teach Pendent	Working Model	01
4	End effectors	Working Model	01
5	Computer system with internet connection	--	01
6	Speakers for listening audio from the Robotic Systems film	--	01

IX. Precautions to be followed

1) Students must follow following precautions during plant visit for Robotic Systems
2) Follow safety precautions given by the industry officials.
3) Wear proper college uniform and safety shoes.
4) Don’t touch any instruments or machine in Industry premises without prior permission from authority
5) Observer discipline during entire visit and walking in Industry.
6) Follow safety instructions given by the subject teacher.
7) Maintain safe distance from operating equipment.

X. Procedure

1) Record the observation from the plant visit
2) Observe the video film regarding Robotic Systems.
3) Prepare group of 3 to 4 students for the presentation on findings of robotics trends in Industry 4.0 and Smart Manufacturing.
4) Each group will present the selected topic for 5 minutes with minimum 10 slides.

XI. Observations

Part A):

Name of Industry Visited: ____

Address of the Industry:

____

____

Sr. No.	Robot Elements	Functions of elements	Use of elements in Industry you visited
1	Manipulator		
2	Robot Arm		
3	Drive System		
4	End Effector (Gripper or Tool)		
5	Sensors		
6	Computer for Control		
7	Power Supply		
8	Programming and Control Software		

Part B): Presentation in a group on findings of robotics trends in Industry 4.0 and Smart Manufacturing.

Name of topic selected for presentation: ____

Name of group members:

1) …………………………………………….
2) …………………………………………….
3) …………………………………………….
4) …………………………………………….

XII. Results

Learning from Robot system Video film or Plant Visit: ---

Learning from robotics trends Presentation: ---

XIII. Interpretation of Results

XIV. Conclusions and Recommendation

XV. Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1) Explain how the configuration of a robot influences its workspace and degrees of freedom.
2) Describe the function of each major robotic element sensors, actuators, drive system, end effector, and controller
3) Illustrate how robotics integrates with Industry 4.0

[Space for Answer]

XVI. References / Suggestions for Further Reading

1) https://www.nist.gov/blogs/manufacturing-innovation-blog/4-types-robots-every-manufacturer-should-know
2) https://www.plantautomation-technology.com/articles/types-of-robots-based-on-configuration
3) https://youtu.be/D9J3rvK-AI8?si=xz26_L31PMI8fPcS
4) https://youtu.be/t8ejdPMqpZQ?si=XlFC6O0lwZvl6W_D
5) https://youtu.be/u2BfVmmaWvk?si=jf494NvZ_ITUmLdX

XVII. Rubrics for Assessment Scheme

Performance Indicators		Weightage
Process Related(15Marks)		**(60%)**
1.	Understanding and Observation of Robot Elements	30%
2.	Participation, Teamwork, and Application of Knowledge in Presentation	30%
Product Related(10Marks)		**(40%)**
3.	Interpretation of result.	20%
4.	Rubrics related questions.	20%
	Total	**100%**

Marks Obtained			**Dated signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 15

Establish networking between CNC Machines, computers and supported peripherals of your Institute to exchange the manufacturing data and produce simple component.

I. Practical Significance:

This experiment demonstrates how to create a **networked production setup** that enables the exchange of design data (CAD/CAM files), part programs, and performance feedback between CNC machines and computers.

II. Industry/Employer Expected Outcome(s)

Apply skills related to Computer-Integrated Manufacturing Systems in real-world manufacturing environment.

III. Course Level Learning Outcome(s) (CO)

CO4 - Use different software and hardware in CIM efficiently.

IV. Laboratory Learning Outcome(s)

LLO 15.1 Select suitable networking peripherals/components to establish network.

LLO 15.2 Set up networking of CNC machines, computers and other devices using the relevant method efficiently.

V. Relative Affective Domain related Outcome(s)

- Work effectively in a team.
- Follow safety and ethical laboratory practices.
- Demonstrate responsibility while handling CNC machines and computer peripherals.
- Exhibit teamwork while configuring shared manufacturing systems.

VI. Minimum Theoretical Background with diagram (if required)

In a Computer Integrated Manufacturing (CIM) environment, networking serves as the vital link connecting various computer-controlled subsystems such as CAD/CAM workstations, CNC machines, robots, material handling systems, and quality inspection stations into a unified digital manufacturing system. It enables seamless data exchange among design, planning, and production units, ensuring accuracy, consistency, and automation in the entire manufacturing cycle.

Types of Networks in CIM:

1) **LAN (Local Area Network):** Used to connect computers and CNCs within the same laboratory or plant.
2) **WAN (Wide Area Network):** Used for remote plant or cloud connectivity.
3) **Ethernet-based Networking:** The most common system used for CNC–computer communication.
4) **DNC (Direct Numerical Control):** Connects a central computer to multiple CNC machines for part program download/upload.

VII. Experimental setup

1) Establish a LAN network between available CNC machines and PCs using Ethernet cables or a switch.
2) Configure IP addresses for all connected systems.
3) Verify communication using ping or DNC software.
4) Load a sample part program (.NC or .ISO file) from the computer to the CNC controller.

5) Execute the machining operation and monitor data exchange logs.
6) Collect performance data such as machining time, tool change commands, and spindle RPMs.

VIII. Required Resources/Apparatus/Equipment with specification

Sr. No.	Equipment / Software	Specification / Description	Quantity
1	Computer System	Minimum 4 GB RAM, Ethernet port, Windows/Linux OS	2 Nos.
2	CNC Turning / Milling Trainer	With Ethernet/DNC communication capability	1–2 Nos.
3	Ethernet Switch / Hub	8-port, 10/100/1000 Mbps	1 No.
4	CAT6 Ethernet Cable	Standard shielded LAN cable	As required
5	DNC Communication Software	Free Educational version or equivalent	1 License
6	CIM / CNC Simulation Software	Free Educational version	1 License
7	Measuring Instruments	Vernier Caliper, Micrometer (for component verification)	As required

IX. Precautions to be followed

1) Ensure that all CNC machines are properly grounded before connecting communication cables.
2) Avoid bending or stretching LAN cables excessively.
3) Use static-free connections when connecting computer ports.
4) Verify network IP settings and avoid duplication of addresses.
5) Ensure that the CNC emergency stop and safety interlocks are active before data transmission.

X. Procedure

1) Identify the CNC machines and computers available for networking.
2) Arrange and connect devices using an Ethernet switch and CAT6 cables.
3) Assign unique IP addresses to each device.
4) Configure DNC or communication software on the computer.
5) Connect to CNC controllers via serial/Ethernet port as applicable.
6) Transfer a sample part program to the CNC memory.
7) Execute machining and verify data flow from PC to CNC.
8) Observe tool movement and part completion.
9) Record data communication status and machining outcome.

XI. Observations

Parameters	CNC Machine 1	CNC Machine 2
Machine IP Address		
Communication Status (Ping Test)		

File Transfer Time (sec)		
Machining Time (min)		
Remarks / Errors Observed		

XII. Results

XIII. Interpretation of Results

XIV. Conclusions and Recommendation

XV. Practical Related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified Course Outcome (CO).

1) Explain the importance of networking in a Computer Integrated Manufacturing (CIM) environment.
2) Identify the basic components required to set up a CNC communication network in a laboratory.
3) Describe the function of a network switch in connecting CNC machines and computers.

[Space for Answer]

XVI. References / Suggestions for Further Reading

1) https://cnc-cn.de/en/networking-cnc-machines-the-path-to-the-smart-factory/
2) https://youtu.be/QnthcR_RZsM?si=5XB25Ah-MH_UVO5z
3) https://youtu.be/k6im47Pq1iU?si=YN1nkPdLNi5KH2WZ

XVII. Rubrics for Assessment Scheme

	Performance Indicators	**Weightage**
	Process Related(15Marks)	**(60%)**
1.	Correctly select networking peripherals/components to establish network.	30%
2.	Set up the networking of CNC machines.	30%
	Product Related(10Marks)	**(40%)**
3.	Interpretation of the result.	20%
4.	Rubrics-related questions.	20%
	Total	**100%**

Marks Obtained	**Dated signature of Teacher**

Process Related (15)	**Product Related (10)**	**Total (25)**	