



**GANESH INSTITUTE OF ENGINEERING & TECHNOLOGY,
POLYTECHNIC, BBSR**

DEPARTMENT OF MECHANICAL ENGINEERING

LECTURER NOTES

COMPUTER-INTEGRATED MANUFACTURING (CIM)

DIPLOMA in 4TH SEMESTER

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CHAPTER-1

Computer Integrated Manufacturing

(CIM) is a manufacturing approach where **computers are used to control, coordinate, and integrate all stages of the manufacturing process**—from product design to production and business operations.

Concept of CIM

CIM aims to **link all manufacturing activities through computer systems** so that information flows smoothly and decisions can be automated or optimized. Instead of each department working separately, CIM creates a **single, integrated system**.

Main Elements of CIM

1. **Computer-Aided Design (CAD)**
 - Used to design products digitally
 - Example: 2D/3D models of parts
2. **Computer-Aided Manufacturing (CAM)**
 - Converts designs into machine instructions
 - Controls CNC machines, robots, etc.
3. **Computer-Aided Process Planning (CAPP)**
 - Plans manufacturing steps, tools, and methods
4. **Flexible Manufacturing System (FMS)**
 - Automated machines that can produce different products with minimal setup changes
5. **Robotics and Automation**
 - Used for material handling, assembly, welding, painting, etc.
6. **Manufacturing Execution System (MES)**
 - Monitors and controls production on the shop floor
7. **Enterprise Systems (ERP)**
 - Integrates business functions like inventory, scheduling, finance, and sales

◆ How CIM Works (Flow)

Design → Planning → Production → Inspection → Storage → Distribution

All these stages are connected through a **central computer database**.

◆ Objectives of CIM

- Increase productivity
- Improve product quality
- Reduce production time
- Minimize human error
- Lower manufacturing cost
- Enable quick response to market changes

Advantages of CIM

- ✓ Better coordination between departments
- ✓ Faster product development
- ✓ High accuracy and consistency
- ✓ Reduced labor and material waste
- ✓ Improved decision-making

Disadvantages of CIM

- ✗ High initial investment
- ✗ Requires skilled workforce
- ✗ Complex system maintenance
- ✗ Risk of system failure or cyber issues

◆ Example of CIM

An automobile factory where:

- Cars are designed using CAD
- CNC machines manufacture parts using CAM
- Robots assemble components
- Computers monitor quality and inventory
- ERP systems manage orders and delivery

All systems work together automatically.

1. Basic Components of CIM

CIM consists of several **integrated subsystems** working together through computers and networks.

- (a) Design and Engineering
 - **CAD (Computer-Aided Design)** – product design and modeling
 - **CAE (Computer-Aided Engineering)** – analysis and simulation
- (b) Manufacturing Systems
 - **CAM (Computer-Aided Manufacturing)**
 - **CNC/DNC machines**
 - **Robots and automation**
 - **Flexible Manufacturing Systems (FMS)**
- (c) Planning and Control
 - **CAPP** – process planning
 - **Production planning and scheduling**
 - **Inventory control**
- (d) Business and Management Systems
 - **ERP / MRP-II**
 - Order processing, finance, marketing
- (e) Integration Infrastructure
 - **Distributed databases**
 - **Communication systems and computer networks**

2. Distributed Database System in CIM

A **distributed database system** stores manufacturing data at **multiple locations** connected through a network, instead of a single central database.

Features:

- Data is shared across departments (design, production, quality, inventory)
- Each location has local control but global access

Advantages:

- Faster data access
- Improved reliability and fault tolerance
- Better data consistency across CIM systems
- Supports real-time decision making

Example:

- Design data at CAD station
- Production data at shop floor
- Inventory data at warehouse
(All connected and synchronized)

3. Distributed Communication System

A **distributed communication system** enables **data exchange between machines, computers, and control systems** in CIM.

Functions:

- Transfers design, control, and status information
- Enables coordination among subsystems

Components:

- Communication protocols
- Network interfaces
- Controllers and sensors

Benefits:

- Real-time monitoring
- Faster response to changes
- Improved system coordination

4. Computer Networks for Manufacturing

Computer networks form the **backbone of CIM integration**.

Types of Networks Used:

- **LAN (Local Area Network)** – within factory
- **MAN/WAN** – between plants or offices
- **Industrial Networks** – Fieldbus, Ethernet, etc.

Roles in CIM:

- Machine-to-machine communication
- Data sharing among departments
- Remote monitoring and control
- Integration of CAD, CAM, MES, and ERP

5. Future Automated Factory

The future factory is often called a “**Smart Factory**”.

Key Characteristics:

- Fully automated and integrated systems
- Extensive use of **AI, IoT, and robotics**
- Minimal human intervention
-
- Real-time decision making
- Self-diagnosing and self-correcting machines

Features:

- Digital twins
- Autonomous robots
- Predictive maintenance
- Mass customization

. Social and Economic Factors of CIM

Social Factors:

- Reduced manual labor
- Need for skilled workforce
- Changes in job roles (more technical jobs)
- Training and re-skilling requirements
- Possible job displacement concerns

Economic Factors:

- High initial investment
- Lower long-term operating costs
- Improved productivity and quality
- Faster time-to-market
- Increased global competitiveness

CHAPTER-2

Definition of CAD

Computer Aided Design (CAD) is the use of **computer systems to create, modify, analyze, and optimize a design.** It helps engineers and designers produce accurate drawings and 3D models efficiently.

2. Purpose of CAD

- To improve **design accuracy**
- To reduce **design time**
- To easily modify designs
- To improve communication between design and manufacturing
- To support integration with CAM and CIM systems

3. Basic Components of a CAD System

(a) Hardware

- Computer (CPU, memory, storage)
- Input devices: keyboard, mouse, digitizer, scanner
- Output devices: monitor, printer, plotter

(b) Software

- CAD software (AutoCAD, SolidWorks, CATIA, etc.)
- Operating system
- Application programs for modeling and drafting

(c) Human (User)

- Designers, engineers, draftsmen

4. Types of CAD Systems

(a) 2D CAD

- Used for drafting and layout drawings
- Example: floor plans, mechanical drawings

(b) 3D CAD

- Used for solid and surface modeling
- Allows visualization and simulation

5. CAD Modeling Techniques

1. Wireframe Modeling

- Uses lines and curves
- Simple but less realistic

2. Surface Modeling

- Defines outer surfaces
- Better visualization

3. Solid Modeling

- Complete 3D representation
- Most widely used in modern CAD

6. Functions of CAD

- Geometric modeling
- Dimensioning and annotation
- Assembly design
- Design analysis (stress, motion, thermal)
- Design optimization
- Drafting and documentation

7. Advantages of CAD

- ✓ High accuracy and consistency
- ✓ Easy design modification
- ✓ Reduced design time
- ✓ Improved productivity
- ✓ Better design quality
- ✓ Easy data storage and reuse

8. Limitations of CAD

- X High initial cost
- X Requires skilled operators
- X Dependence on computer systems
- X Software compatibility issues

9. Applications of CAD

- Mechanical design
- Electrical and electronic design
- Civil and architectural design
- Automotive and aerospace industries
- Product design and development

10. CAD in CIM Environment

- CAD provides design data to **CAM**
- Helps in **process planning (CAPP)**
- Forms the foundation for **Computer Integrated Manufacturing (CIM)**

1. CAD Hardware and Software

(a) CAD Hardware

CAD hardware provides the **physical platform** for design activities.

Input Devices

- Keyboard
- Mouse
- Digitizer
- Scanner
- Light pen

Processing Unit

- High-speed CPU
- Graphics processor (GPU)
- Main memory and secondary storage

Output Devices

- Monitor (high-resolution graphics display)
- Printer
- Plotter

(b) CAD Software

CAD software performs **design, drafting, modeling, and analysis**.

Types of CAD Software

- System software (Operating system)
- Application software (AutoCAD, SolidWorks, CATIA, Creo)

Functions

- Geometric modeling
- Drafting and detailing
- Assembly modeling
- Engineering analysis
- Interface with CAM and CAE

2. Product Modelling

Product modelling is the creation of a **digital representation of a product** in CAD.

Types of Product Models:

1. **Geometric Model**
 - Shape and size of the product
2. **Feature-based Model**
 - Design features like holes, slots, fillets
3. **Parametric Model**
 - Dimensions controlled by parameters
4. **Solid Model**
 - Complete 3D representation

Advantages:

- Easy modification
- Reuse of design data
- Better visualization
- Integration with manufacturing

3. Automatic Drafting

Automatic drafting uses CAD to generate **engineering drawings automatically** from models.

Features:

- Automatic dimensioning
- Standard symbols and templates
- Sectional and exploded views
- Error reduction
- Faster drawing generation

Benefits:

- High accuracy
- Reduced drafting time
- Consistency in drawings

4. Engineering Analysis (CAD/CAE)

Engineering analysis evaluates the **performance of a design** before manufacturing.

Types of Analysis:

- Stress and strain analysis
- Thermal analysis
- Vibration and dynamic analysis
- Fluid flow analysis

Benefits:

- Detects design flaws early
- Reduces prototype cost
- Improves product reliability

5. FEM (Finite Element Method)

Concept:

FEM divides a complex structure into **small finite elements** to analyze behavior under loads.

Steps in FEM:

1. Pre-processing (modeling, meshing)
2. Applying loads and boundary conditions
3. Solving equations
4. Post-processing (results interpretation)

Applications:

- Structural analysis
- Heat transfer
- Fatigue analysis

6. Design Review and Evaluation

Design review ensures the product meets **functional, safety, and quality requirements**.

Methods:

- Visual inspection using 3D models
- Simulation and analysis results
- Interference and tolerance checks
- Design for manufacturability (DFM)
- Design for assembly (DFA)

Outcomes:

- Improved design quality
- Reduced rework
- Better collaboration

7. Group Technology (GT) Centre

Definition:

Group Technology is a manufacturing philosophy where **similar parts are grouped into families** based on design and manufacturing similarities.

GT Centre Functions:

- Classification and coding of parts
- Standardization of designs
- Efficient process planning
- Reduced setup time
- Improved productivity

Role of CAD in GT:

- Part classification using CAD models
- Retrieval of standard designs
- Integration with CAPP and CAM

8. Summary (Exam-Oriented)

- CAD hardware and software enable design creation and processing
- Product modeling forms the core of CAD systems
- Automatic drafting improves speed and accuracy
- Engineering analysis and FEM validate designs
- Design review ensures manufacturability and quality
- Group Technology improves efficiency through part standardization

CHAPTER-3

Definition

CAM (Computer-Aided Manufacturing) is the use of computer software and systems to **control and automate manufacturing processes**. It converts designs created in CAD (Computer-Aided Design) into instructions for machines that produce the physical parts.

In simpler words:

- **CAD** = design the product on the computer.
- **CAM** = tell the machine exactly **how to make** that product.

How CAM Works

1. **Design Input:**
 - The design of the part or product is created in CAD software.
2. **Process Planning:**
 - CAM software generates a **toolpath**, which is the exact route the cutting tool or machine will follow.
3. **Machine Control:**
 - The software translates the toolpath into **G-code or M-code**, which the machine understands.
4. **Production:**
 - The machine (like a CNC mill, lathe, or 3D printer) executes the instructions to produce the part.

Key Components of CAM

1. **Software:**
 - Examples: Mastercam, Fusion 360, SolidCAM, NX CAM.
2. **Hardware:**
 - CNC machines, 3D printers, laser cutters, robotic arms.
3. **Post-Processor:**
 - Converts CAM data into machine-readable code (G-code/M-code).

Advantages of CAM

- **Accuracy & Precision:** Machines follow exact instructions.
- **Efficiency:** Faster production than manual machining.
- **Complex Designs:** Can produce shapes that are very hard to make manually.
- **Consistency:** Every part is identical.
- **Integration with CAD:** Directly uses CAD designs for manufacturing.

Disadvantages of CAM

- **High Cost:** Software and machines are expensive.
- **Skilled Operators Needed:** Operators must understand CAM software and machines.
- **Maintenance:** Machines require regular upkeep.

Examples of CAM in Use

- CNC milling of engine parts
- 3D printing of medical implants
- Laser cutting of metal sheets
- Robotic assembly lines in car manufacturing

Computer-Assisted NC Part Programming for Turning

NC (Numerical Control) is a way to control machine tools using a set of instructions called **part programs**. When you use a computer to help create these programs, it's called **Computer-Assisted NC Programming (CNC programming using CAM software)**.

a) Plain Turning

- **Definition:**
Plain turning is when a cylindrical workpiece rotates, and a cutting tool moves **parallel to the axis** to reduce diameter.
- **Computer-Assisted Programming Steps for Plain Turning:**
 1. Create the **part design** in CAD.
 2. Import the design into CAM software.
 3. Select **tooling** (cutting tool type, size, speed, and feed).
 4. Define **machining operation** → in this case, straight turning.
 5. CAM software generates **tool paths** along the axis.
 6. Post-process to generate **G-code** for the lathe.
- **Example Tool Path:** The tool moves **linearly along the length** of the cylinder while the workpiece rotates.

b) Step Turning

- **Definition:**
Step turning is turning a workpiece with **different diameters** along its length, creating "steps."
- **Computer-Assisted Programming Steps for Step Turning:**
 1. CAD design shows **different diameters** along the length.

2. CAM software generates **toolpaths for each step**, including cutting lengths and diameters.
3. Assign cutting parameters for **each step**.
4. Generate **G-code** for the CNC lathe.

- **Example:** A shaft with three different diameters along its length → CAM software calculates the cutting paths for each section.

Advantages of Computer-Assisted NC Programming:

- Reduces human error.
- Faster program creation.
- Can simulate the cutting process before actual machining.

Computer-Assisted Robot Programming

Robots are programmed to perform tasks like welding, assembly, painting, or material handling. **Computer-assisted programming** simplifies robot control.

Steps for Computer-Assisted Robot Programming

1. **Model the Workspace:**
 - Use CAD or simulation software to create the robot's environment.
2. **Define Tasks:**
 - Pick up, move, weld, assemble, or place objects.
3. **Path Planning:**
 - Computer calculates the **robot's trajectory** and joint movements.
4. **Program Generation:**
 - CAM-like software generates **robot code** (e.g., RAPID for ABB, KRL for KUKA robots).
5. **Simulation & Testing:**
 - Check for collisions or mistakes in software before running the robot physically.

Advantages:

- Avoids trial-and-error on the real robot.
- Reduces downtime.
- Increases safety by detecting collisions before operation.

Summary

Topic	What It Does	Example
Plain Turning	Reduce diameter along the length	Cylinder rod
Step Turning	Make shafts with different diameters	Gear shaft
Robot Programming	Move robot arms efficiently	Welding car parts

Computer-Aided Process Planning (CAPP)

Definition:

CAPP is the use of computer systems to plan the manufacturing processes needed to make a product. It helps determine the sequence of operations, machines, tools, and resources required to produce a part or product efficiently.

Key Points:

- Bridges **design and manufacturing**.
- Reduces manual planning errors.
- Improves productivity and consistency.
- Can be **Variante CAPP** (using predefined templates) or **Generative CAPP** (creating new plans automatically based on product design).

Example:

If you want to manufacture a metal gear:

- CAPP helps decide **which machines** to use (lathe, milling, grinding),
- **Order of operations** (cutting → drilling → finishing),
- **Tools** needed (drill size, cutting tools), and
- **Time estimates** for each operation.

Benefits:

- Faster production planning.
- Lower manufacturing cost.
- Better utilization of machines and labor.
- Reduced lead time.

Computer-Aided Material Requirements Planning (MRP)

Definition:

MRP is a computer-based system used to calculate **material requirements** and schedule their delivery to meet production needs. It ensures the right materials are available at the right time without overstocking.

Key Points:

- Based on **BOM (Bill of Materials)**, inventory data, and production schedule.
- Helps plan **what to buy, when to buy, and in what quantity**.
- Reduces excess inventory and shortages.

Example:

If a factory needs to produce 100 bicycles:

- MRP calculates **how many wheels, frames, chains, and seats** are needed.
- Checks current stock in inventory.
- Generates purchase orders for missing parts and schedules their delivery.

Benefits:

- Optimizes inventory levels.
- Minimizes material shortages.
- Reduces storage costs.
- Helps meet production deadlines efficiently.

CHAPTER-4

Definition

Computer-Aided Production Scheduling (CAPS) is the use of computer software to **plan, organize, and control the sequence of manufacturing operations** so that products are made **efficiently, on time, and using resources optimally**.

In simple terms:

It's a computer system that decides **what to make, when to make it, and in what order**, so factories don't waste time or materials.

2. Purpose of Production Scheduling

- **Meet deadlines:** Ensure products are finished on time.
- **Optimize resources:** Machines, labor, and materials are used efficiently.
- **Reduce idle time:** Machines and workers aren't waiting around.
- **Minimize inventory costs:** Avoid overproduction.
- **Balance workloads:** Prevent overloading some machines while others sit idle.

3. How Computer-Aided Production Scheduling Works

1. **Input Data:**
 - Orders, delivery dates, machine capacity, labor availability, material inventory.
2. **Processing by Software:**
 - Software uses algorithms (like **Gantt charts, critical path, or priority rules**) to schedule tasks.
3. **Output Schedule:**
 - Detailed plan showing:
 - Which machine will do which job
 - When each job starts and ends
 - Task priority if there are conflicts

4. Methods Used in CAPS

1. **Finite Capacity Scheduling (FCS):**
 - Considers **machine limitations** and schedules jobs only when machines are available.
2. **Just-In-Time (JIT) Scheduling:**
 - Produces products **exactly when needed**, reducing inventory.
3. **Priority Rules:**
 - Earliest due date (EDD)
 - Shortest processing time (SPT)
 - First come, first served (FCFS)
4. **Simulation:**
 - Test different production scenarios to **find the best schedule** before implementing it on the factory floor.

5. Advantages of Computer-Aided Production Scheduling

- Reduces production delays
- Improves **machine and labor efficiency**
- Minimizes material waste and inventory costs
- Allows **quick response** to changes (like urgent orders)
- Can simulate "what-if" scenarios

6. Example

Imagine a factory making 3 types of toys: A, B, and C:

- Machine 1 → used for all toys
- Machine 2 → only for toy B and C

The software will:

- Decide the **order of production**
- Allocate machines so **no waiting occurs**
- Predict **completion times** for each toy
- Adjust the schedule if **urgent orders** arrive

Computer-Aided Inspection Planning (CAIP)

Definition:

CAIP is the use of computer systems to plan and organize the inspection of products to ensure they meet quality standards. It defines **what to measure, how to measure it, and when to inspect** during production.

It's basically like CAPP, but for **quality control** instead of manufacturing.

Key Points

1. **Purpose:**
 - Ensures products meet specifications.
 - Reduces defects and rework.
 - Standardizes inspection procedures.
2. **Inputs:**
 - Product design / CAD models.

- Tolerances and specifications.
- Inspection standards and instruments.
- 3. **Outputs:**
 - Inspection plan with **operations, measurements, and checkpoints**.
 - List of **tools and instruments** to be used.
 - Reporting format for recording inspection results.
- 4. **Types of Inspection Planning:**
 - **Dimensional Inspection:** Measures size, shape, and position.
 - **Visual Inspection:** Checks surface finish, color, or defects.
 - **Functional Inspection:** Verifies product works as intended.
- 5. **Benefits:**
 - Faster and more accurate inspection planning.
 - Consistent quality standards.
 - Helps in **automated inspection systems** like CMM (Coordinate Measuring Machines).
 - Reduces human errors and missed defects.

Example:

For a car engine part:

- CAIP can specify:
 - Measure bore diameter with micrometer.
 - Check flatness of the mounting surface using a CMM.
 - Inspect threads visually and with gauges.
- Outputs a **step-by-step inspection plan** so the quality team knows exactly what to do.

Relation to CAPP and MRP

- **CAPP** → Plans **how to make** the product.
- **MRP** → Plans **materials needed** to make it.
- **CAIP** → Plans **how to check** the product is correct.

Computer-Aided Inventory Planning

Definition:

Computer-Aided Inventory Planning is the use of computer systems to **manage and control inventory** efficiently. It ensures that a company has the **right amount of materials or products at the right time**—not too much (which wastes money) and not too little (which delays production or sales).

It's closely related to **MRP**, but focuses more broadly on inventory management rather than just production materials.

Key Points

1. **Purpose:**
 - Maintain optimal stock levels.
 - Avoid stockouts or excess inventory.
 - Improve cash flow by not tying up money in unused stock.
2. **Inputs:**
 - Current inventory levels.
 - Sales forecasts or production schedules.
 - Lead time for suppliers.
 - Reorder points and safety stock levels.
3. **Outputs:**
 - Recommended **order quantities**.
 - **Reorder alerts** for low stock.
 - Inventory reports for management.
4. **Techniques Used:**
 - **EOQ (Economic Order Quantity):** Calculates optimal order size.
 - **ABC Analysis:** Classifies items based on value and usage (A = most valuable, C = least).
 - **Safety Stock Calculation:** Ensures backup stock for uncertainties.
 - **Reorder Point Calculation:** Tells when to order more stock.

Example:

A factory produces toys:

- Current stock of wheels = 500 units.
- Production plan requires 1000 wheels next month.
- CAIP system calculates:
 - Order 600 wheels now.
 - Keep 100 wheels as safety stock in case of delays.
- Generates a **purchase order automatically** and updates inventory records.

Benefits:

- Reduces holding costs and waste.
- Prevents production delays due to missing materials.
- Provides accurate, real-time inventory tracking.

- Supports better decision-making for purchasing and production planning.

• **Flexible Manufacturing System (FMS)**

Definition:

A **Flexible Manufacturing System (FMS)** is a **computer-controlled manufacturing system** designed to produce a variety of products in small to medium quantities with minimal manual intervention. It can quickly adapt to changes in product type, design, or production volume.

Think of it as a **highly automated, smart factory** that can switch between making different products without stopping for long retooling times.

Key Features of FMS

1. **Automation:** Uses robots, CNC machines, and computer control.
2. **Flexibility:** Can produce different products without major changes.
3. **Integration:** Combines machines, material handling, and computers.
4. **Efficient Material Handling:** Uses automated conveyors, robots, or AGVs (Automated Guided Vehicles).
5. **Computer Control:** Plans production, monitors machines, and schedules tasks.

Advantages of FMS

- Reduces setup and production time.
- Can handle **product variety** easily.
- Improves productivity and reduces labor costs.
- Minimizes human error.
- Better utilization of machines and resources.

Example:

A factory makes car parts like gear shafts and engine blocks:

- FMS can switch from producing gear shafts to engine blocks **without stopping for hours to change machines**.
- The system automatically adjusts tools, machine settings, and schedules material movement.

Concept of Flexible Manufacturing

Definition:

Flexible manufacturing refers to a **manufacturing system's ability to adapt quickly** to changes in:

- **Product type** (making different products)
- **Production volume** (increasing or decreasing quantity)
- **Product design** (modifying design without major downtime)

Types of Flexibility

1. **Machine Flexibility:** One machine can perform multiple operations.
2. **Routing Flexibility:** Products can follow different paths through machines.
3. **Volume Flexibility:** Production can be scaled up or down easily.
4. **Mix Flexibility:** Can produce different products at the same time.

Benefits of Flexible Manufacturing

- Meets changing customer demands faster.
- Reduces production downtime.
- Increases competitiveness.
- Supports mass customization (making products to order in smaller batches).

Summary Table: FMS vs Flexible Manufacturing Concept

Feature	FMS	Flexible Manufacturing (Concept)
Definition	Computer-controlled system for automated production	Ability of a manufacturing system to adapt to changes
Focus	Automation + integration of machines and material handling	Flexibility in product, volume, and process
Goal	Efficient production of varied products	Quick adaptation to changes in design or demand
Example	CNC machines + robots making car parts	Factory can switch from one product type to another quickly

CHAPTER-5

What Does “Integrating NC Machines” Mean?

Integration of NC machines means connecting multiple CNC (Computer Numerical Control) machines together—or connecting them with other systems in a factory—so they can:

- Work in a **coordinated way**
- Share **information automatically**
- Follow a **centralized production plan**

Instead of each machine working **independently**, integration makes the whole manufacturing process **more efficient** and **automated**.

2. Why Integrate NC Machines?

- **Reduce idle time:** Machines can work in sequence without waiting for manual instructions.
- **Improve productivity:** Programs and instructions can be shared automatically.
- **Reduce errors:** Eliminates manual entry mistakes.
- **Central control:** Supervisors can monitor multiple machines at once.
- **Flexibility:** Easier to adapt production when orders change.

3. Types of NC Machine Integration

a) Machine-to-Machine Integration

- Machines are connected **directly** to each other.
- Example: One CNC lathe produces a part, then automatically passes it to a CNC milling machine.

b) Machine-to-CAD/CAM Integration

- CAM software sends **part programs directly** to machines.
- No manual programming needed at the machine.
- Reduces setup time.

c) Machine-to-ERP/MES Integration

- **ERP (Enterprise Resource Planning)** or **MES (Manufacturing Execution System)** sends schedules and instructions to NC machines.
- Machines report **status and progress** back automatically.

4. Methods of Integration

1. Direct Numerical Control (DNC)

- Machines are connected to a **central computer** that sends programs directly.
- Example: Central computer → 5 CNC lathes → programs sent automatically.

2. Networked CNC Machines

- Machines connected over a network (LAN/WAN).
- Can **share programs, tooling info, and production data**.

3. Flexible Manufacturing System (FMS)

- Multiple NC machines + robots + automated material handling integrated.
- The system can produce different parts **without stopping** for reprogramming.

5. Advantages of Integrating NC Machines

- Faster production
- Lower labor costs (less manual intervention)
- Higher accuracy and consistency
- Better tracking of production and machine status
- Easier scheduling and optimization

6. Example

Imagine a factory making engine parts:

1. **CNC Lathe:** Turns shafts
 2. **CNC Milling Machine:** Cuts keyways
 3. **CNC Drill:** Drills holes
- **Integrated system:**

What is a Robot?

A **robot** is a programmable machine that can **perform tasks automatically**. These tasks are usually repetitive, dangerous, or require high precision.

2. Types of Robots

Robots are used in many areas, but in manufacturing and industry, the main types are:

1. Industrial Robots

- Used in factories for tasks like welding, painting, assembly, or packaging.
- Example: A robotic arm welding car parts.

2. Service Robots

- Assist humans outside of factories, like in hospitals or homes.
- Example: Cleaning robots or delivery robots.

3. Mobile Robots

- Can move around, sometimes guided automatically.

- Example: AGVs (Automated Guided Vehicles) in warehouses.

3. Components of a Robot

A robot usually has:

1. **Manipulator (Arm or Body):** Performs the action.
2. **Controller (Brain):** A computer that gives instructions.
3. **Sensors:** Help the robot detect objects or environment changes.
4. **Actuators (Motors):** Make the robot move.

4. Advantages of Robots

- Work continuously without fatigue.
- Perform tasks with high accuracy.
- Can operate in dangerous environments.
- Reduce human labor in repetitive tasks.

5. Examples in Industry

- Robotic arms in car manufacturing.
- Packaging robots in food industries.
- Welding robots in electronics assembly.

What is an AGV?

An **Automated Guided Vehicle (AGV)** is a **mobile robot** used to **transport materials** in factories, warehouses, or distribution centers **without human intervention**.

Think of it as a self-driving cart for moving goods.

2. How AGVs Work

AGVs move along a **predetermined path** using guidance systems such as:

1. **Wired Guidance:** Follows wires embedded in the floor.
2. **Laser Guidance:** Uses lasers and sensors to navigate.
3. **Magnetic Tape:** Follows magnetic strips on the floor.
4. **Vision-Based Navigation:** Uses cameras to map the environment.

3. Types of AGVs

1. **Towing AGVs:** Pull trailers or carts.
2. **Unit Load AGVs:** Carry pallets or boxes on top.
3. **Forklift AGVs:** Lift and transport pallets like a small forklift.
4. **Assembly Line AGVs:** Move parts between workstations in a factory.

4. Advantages of AGVs

- Operate **24/7** without breaks.
- **Reduce labor costs** for material handling.
- **Increase safety** by avoiding human errors in transport.
- Can be **integrated with inventory and production systems**.

5. Examples in Industry

- Car factories: Move parts between assembly stations.
- Warehouses (like Amazon): Transport packages automatically.
- Hospitals: Deliver medicines or supplies.

NC Equipment (Numerical Control Equipment)

- **Definition:** Machines that operate automatically according to programmed instructions (usually from a computer).
- **Purpose:** To perform precise and repetitive manufacturing tasks.
- **Examples:**
 - CNC machines (Computer Numerical Control) for cutting, drilling, or milling.
 - Lathes and milling machines that follow exact dimensions.
- **Advantage:**
 - High precision and repeatability.
 - Reduces human error.
 - Works continuously without fatigue.

2. Computer-Aided Quality Control (CAQC)

- **Definition:** Using computers to monitor, inspect, and ensure product quality.
- **How it works:**
 - Sensors measure dimensions, weight, or other properties.
 - Data is compared to specifications automatically.
- **Examples:**
 - Checking if a car part matches exact measurements.
 - Detecting defective products on a production line.
- **Advantage:**

- Consistent product quality.
- Faster inspection than manual checking.

3. Business Functions & Computer-Aided Forecasting

- **Business Functions:** Activities like production planning, inventory control, sales, and marketing.
- **Computer-Aided Forecasting:** Using software to **predict future trends** like demand, sales, or inventory needs.
- **Examples:**
 - A store predicting how many units of a product to stock for next month.
 - Manufacturing predicting material requirements.
- **Advantage:**
 - Helps in planning and reducing waste.
 - Improves decision-making and efficiency.

4. Office Automation

- **Definition:** Using computers and software to automate office tasks.
- **Examples:**
 - Word processing, spreadsheets, and databases.
 - Managing emails, scheduling meetings, payroll, and records.
- **Advantage:**
 - Saves time and reduces human error.
 - Makes office work more organized and faster.