Mechanics

Level V

Based on December, 2024Curriculum Version2

Module Title: - Planning and Calculating Basic Mechanical Systems Job

Module code: - : IND MCS5 M02 1224

Nominal duration: 40 Hours

Prepared by: Ministry of Labor and Skill

December 2024

Addis Ababa, Ethiopia

Table of Contents

Acknowledgment

The Ministry of Labor and skill wishes to thank and appreciation to MoLS leaders and experts, Regional Labor and skill/training Bureaus leader, experts, TVT College Deans, Instructors and industry experts who contribute their time and professional experience to the development of this Training Module.

Acronyms

CAD - Computer-Aided Design

CAM - Computer-Aided Manufacturing

TDS - Technical Design Specifications

BOM - Bill of Materials

DFM - Design for Manufacturing

DFA - Design for Assembly

RPM - Revolutions Per Minute

FMEA - Failure Mode and Effects Analysis

VFD - Variable Frequency Drive

RMS - Root Mean Square

MTBF - Mean Time Between Failure

CoF - Coefficient of Friction

Introduction to the Module

A mechanical system job is a set of physical components that convert an input motion and force into a desired output motion and force.A mechanical system is a crucial in manufacturing industryprocess input into output. The module provides Research equipment function and operational requirements**,** Calculate construction and processing data**,** Prepare a preliminary sketch/drawing/ specifications and Plan the mechanical system.

This module is designed to meet the industry requirement under **Mechanics** Occupational Standard, particularly for the unit of competency: **Plan and Calculate Basic Mechanical Systems Job.**

This module covers the units:

- Equipment Function and Operational Requirements
- Construction and Processing Data Calculation
- Preliminary Sketch/Drawing/ Specifications
- Mechanical System Planning

Learning Objective of the Module

- Identify Research equipment function and operational requirements
- Calculate construction and processing data
- Prepare a Preliminary Sketch/Drawing/ Specifications
- Determine the Planning of Mechanical System

Module Instruction

For effective use this modules trainees are expected to follow the following module instruction:

1. Read the information written in each unit
2. Accomplish the Self-checks at the end of each unit
3. Perform Operation Sheets which were provided at the end of units.
4. Do the “LAP test” given at the end of unit.
5. Read the identified reference book for Examples and exercise

Unit One: Equipment Function and Operational Requirements

This unit is developed to provide you the necessary information regarding the following content coverage and topics:-

- Drawings, specifications, manuals and documentation.
- Consultation of appropriate personnel.
- Collecting and Interpreting information
- Draft Functional and Operational Requirements Verification

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Identify all relevant drawings, specifications, manuals and documentation are obtained in accordance with workplace procedures.
- Determine appropriate personnel for consulting requirements.
- Interpret the information collected and prepared are prepared
- Verify the draft functional and operational requirements.

1.1Drawings, Specifications, Manuals and Document

1.1.1 Interpreting working drawing

Working drawing is the other name of a production drawing a production drawing, supplies information and instructions for the manufacture or construction of machines or structures. A production drawing should provide all the dimensions, limits, special finishing processes, surface quality, etc. The particulars of material, the number of components required for the assembly, etc., are given in the title block. The production drawing of a component should also indicate the sub-assembly or main assembly where it will be assembled. Since the working drawings may be sent to other companies to make or assemble the unit, the drawings should confirm with the standards followed in the country. For this reason, a production drawing becomes a legal document between the parties, in case of disputes in manufacturing. Working drawings maybe classified into two groups: Detail or part drawings and Assembly drawings

1.1.2 Types of Production Drawing

I) **Detail** or **part drawing** is an engineering drawing that provides a complete, precise description of an individual part. It is a crucial document in manufacturing and assembly processes, giving designers, engineers, and manufacturers the exact information needed to create a specific part .A detail or part drawing is nothing but a production or component drawing, furnishing complete information for the construction or manufacture of the part.

Title Block

- Location: Usually in the bottom right corner of the drawing.
- Contents:
  - Part name and drawing title.
  - Drawing number or part number.
  - Date of drawing creation or revision.
  - Name of the designer/engineer or organization.
  - Material specification (what the part is made of).
  - Scale of the drawing (e.g., 1:1, 1:2, etc.).
  - Tolerances (general tolerances, unless otherwise specified).

II) Assembly Drawings

A machine is an assembly of various links or parts. It is necessary to understand the relation between the various parts of the unit for the purpose of design and production. An assembly drawing is one which represents various parts of a machine in their working position. The final assembly drawings are prepared from design assembly drawings or from the working drawings.

A) Specification the speciation is one part of a bid document either an expression of interest or a request for tender. It can be defined as a document primarily for use in procurement, which clearly and accurately describes the essential requirements for goods, products or services. It may also include the procedures for determining that the requirements have been met. Specifications and procedures requirements and formats are established and confirmed, where necessary. Requirements for information entry, storage, output and quality of document production are identified in accordance with enterprise procedures. Document provides general principles on the setting and justification, to the Extent possible, of a uniform set of international specifications for engineering productstosupportnewmarketingapplications.Beforeyouprepareспецификацияyoushould:

B)

C) Identify customer or user needs through the business plan where appropriate, and give full consideration to their requirements; Research the market,(by making general enquiries of suppliers, purchasers or industry associations, or by placing formal advertisements for Registrations of Interest) to determine currently available solutions to problems ,likely costing and time scales; Assess the risk of a supplier failing to full fill specifications, against the risks of continuing with the existing situation; Identify what is to be procured and confirm that the proposed procurement will full fill the customer or user needs; Determine the scope including the likely demands on a supplier and the range of goods or services which will be required

1.2 Consultation of Appropriate Personnel

After finishing the rough sketch and rough specifications as well as observing document and manuals. You should discuss with an appropriate personnel. And take corrective actions. After taking feed backs and corrective actions revise your project and you can conclude that whether you will continue or not.

Consulting appropriate personnel is a critical step in any project or business process that involves collaboration, decision-making, and problem-solving. This section emphasizes the importance of engaging with the right stakeholders, subject matter experts, and team members to ensure informed decisions and effective outcomes.

Key Considerations for Consulting Appropriate Personnel:

1. **Identify Key Stakeholders**
    - Understand who will be affected by the decision or change, and who has the authority or expertise to provide input. Stakeholders can include:
    - Internal Personnel: Department heads, team leads, project managers, and other employees who have direct knowledge of the task.
    - External Stakeholders: Clients, suppliers, industry consultants, regulatory bodies, and vendors, if applicable.
2. **Assess Expertise**
    - It is essential to identify who has the specific knowledge or experience necessary to contribute to the issue at hand. Examples include:

- Technical Experts: Engineers, IT specialists, or technicians who can provide insights on technical aspects.
- Business Experts: Marketing, finance, operations, and HR professionals who understand the strategic and operational implications.
- Legal and Compliance: Legal advisors or compliance officers who ensure adherence to regulatory requirements.

3. **Determine the Scope of Consultation**

   Clarify the scope of the consultation and ensure that it aligns with the overall objectives of the project or decision. Consider:

   - What information is required?
   - At what stage is consultation needed?
   - How will the input be integrated into the final decision?

4. **Engage in Structured Dialogue**

   Organize formal meetings, workshops, or one-on-one consultations to gather the required input. During these sessions:

   - Prepare an agenda to focus discussions on the key issues.
   - Ensure a collaborative environment where personnel feel comfortable sharing their opinions.
   - Ask clear, targeted questions to gather relevant information.

5. **Leverage Cross-functional Teams**
   - In cases where decisions affect multiple departments, cross-functional collaboration becomes important. Engaging personnel from diverse backgrounds can lead to more comprehensive solutions.
     - For example, product development may require input from R&D, marketing, sales, and finance to ensure feasibility and alignment with market demand and cost constraints.

6. **Document and Communicate Feedback**
   - After consulting with the appropriate personnel, it is critical to document the insights and feedback gathered during the consultation.
     - Keep records of discussions, decisions made, and the rationale behind them.
     - Ensure that the feedback is communicated to all relevant stakeholders to maintain transparency.

7. **Follow Up and Seek Clarifications**

   Ensure that there is a process for following up on the feedback received, especially when implementing complex changes or new systems. Clarify any uncertainties, and make sure that the personnel consulted feel their input was valued and properly integrated into the decision-making process.

Benefits of Consulting Appropriate Personnel:

- Informed Decision-Making: Engaging experts and stakeholders ensures that decisions are based on accurate, up-to-date information and best practices.
- Avoidance of Mistakes: Consulting the right people can help foresee potential problems or gaps in planning, which minimizes risks.
- Increased Buy-in and Support: When people are consulted during the decision-making process, they are more likely to support and implement the outcomes effectively.
- Enhanced Collaboration: It fosters a culture of collaboration and teamwork, improving communication and cooperation across departments.
- Compliance and Alignment: Ensures that all decisions adhere to legal, regulatory, and organizational policies, reducing the risk of non-compliance

1.3 Collecting and Interpreting Information

1.3.1 Draft functions and operational requirement

Preparing draft functions and operational requirement initiates the process by acquiring or developing the information necessary to understand the Information System under evaluation and then using that information to creator products. In preparing drafts we may include sketching, selection of material, budget and work break down structure.

A) Sketching it is the practice of drawing a rough outline or rough draft version of a final piece of art. Sketching can be used in preparation for a large piece of art, or to just get an idea of how something will look. Whether you're sketching for fun or for a project, learning he proper technique can make the practice much more enjoyable.

B) Material selection the designer of any product, other than software must get involved with material selection. Only occasionally will the exact grade of material be specified by the customer. Even then the designer must understand the material to be able to design the product.

C) Budgeting the following items typically appears in total Project Cost estimates for new construction and renovation projects:

D) Soft costs: These costs are associated with project implementation, including consultant services, surveys, testing, printing costs, and miscellaneous reimbursable costs. The largest components of these costs are typically the architect and engineers fees and other professional consultants. Depending on the project specifics, soft costs may include land surveys, soil testing, and specialty consultants such as lab planners, wind tunnel experts, and acoustical engineers. In developing a project budget, FM relies on the knowledge base of past projects of similar size and scope to create an estimate for soft costs.

E) Construction costs: Construction costs include labor, material, equipment, general requirements, contractor's overhead, and mark-up. Projects are typically submitted to a competitive pool of pre- qualified contractors for a lump sum bid. Construction costs also may include temporary utilities, fencing, temporary partitions, and other items required by to ensure safety and minimize occupant disruptions.

Furniture & equipment: Furniture is typically not included in the general contractor's bid. Furniture is purchased through furniture dealers or direct from the manufacturer. Specialty and A/V equipment may be included in the general contractor's contract if it requires permanent connections to the building infrastructure (e.g., fume hoods). Loose equipment is purchased separately from the construction contract.

Moving & storage: Moving costs for offices and labs associated with renovations, new construction, and temporary relocations are included in the project budget. In rare circumstances, project budgets will include the cost of temporary storage of furniture or equipment during renovations.

Permit fees: Building permits fees and other regulatory fees are included in the project budget. The cost of regulatory fees is unknown until calculated by a specific regulatory agency at the time of permit issuance .The City of Evanston will in crease the permit fees at the end of construction to reflect any change orders issued to the general contractor. The final costs are determined long after building occupancy. FM projects fees within the budget based on experience.

Facilities Management Operations charges :FMO charges include the costs of any time or materials spent by the FM Operations shops in conjunction with the project. These costs range from cutting keys, providing access to equipment rooms, assisting in utility shut downs, and reviewing design drawings for conformance with University standards.

Project management fees: FM assesses a graduated fee to cover project management expenses and FM overhead on all projects. The fee is determined by the overall project budget size; it ranges from 2 percent for projects over $50 million to 5 percent for projects under $500,000.Learn more about project management fees.

Contingency: There is no way that every risk can be fully calculated or anticipated. A contingency amount is added to a project budget as an insurance policy to cover the two types of risks: accuracy of estimating against the current market conditions and unforeseen conditions or requirements.

D) Work break down structure (WBS):It is used as a basis for a number of processes in particular to produce the subsidiary plans of the Project Management Plan. The WBS is a deliverable-oriented hierarchy of decomposed project components that organizes and defines the total scope of the project. The WBS is a representation of the detailed project scope statement that specifies the work to be accomplished by the project. The elements comprising the WBS assist the stakeholders in viewing the end product of the project. The work at the lowest-level WBS component is estimated, scheduled, and tracked

1.4 Draft Functional and Operational Requirements Verification

After finishing the rough sketch and rough operational requirement you should discuss with an appropriate Personnel. The budget and work break down structure and operational requirements should be evaluated By professional and expertise personnel and you should defined them your project is realistic and Important because these are mild stones to be success or fail the project.

Verifying operational requirements with the appropriate personnel is a crucial step in ensuring that all elements of a project, system, or process meet the necessary functional and performance standards. This process involves engaging with key stakeholders and subject matter experts to confirm that the operational needs are clearly understood, feasible, and aligned with organizational goals.

Steps for Verifying Operational Requirements:

1. **Identify Operational Requirements**
   - Operational requirements refer to the essential functions, processes, or systems that are necessary to ensure that the organization or project operates effectively. These requirements can include:
     - Performance standards: Speed, quality, capacity, etc.
     - Operational procedures: Steps and processes that must be followed.

- Resource needs: Human resources, materials, equipment, and technology.
- Compliance and safety: Regulatory and legal requirements..

2. **Engage the Appropriate Personnel**
   - Identify the individuals or teams that have the relevant expertise and responsibility for different aspects of the operational requirements. These may include:
     - Operations Managers: To ensure that the requirements align with day-to-day operations.
     - Technical Staff: Engineers, IT personnel, or technicians who understand the technical or functional aspects.
     - Supervisors or Department Heads: Who oversee the operational processes and can provide insights into feasibility and efficiency.
     - Compliance Officers: To verify that operational requirements adhere to legal or regulatory standards.
3. **Conduct Reviews and Assessments**
   - Formal Meetings or Workshops: Arrange discussions or workshops with the identified personnel to review the documented operational requirements.
     - Ensure that all personnel involved understand the operational goals and objectives.
     - Discuss any challenges or limitations they foresee in meeting these requirements.
     - Use checklists or criteria to ensure all operational aspects are covered.
4. **Cross-Check with Organizational Standards**
   - Confirm that the operational requirements align with the organization's broader policies, strategic objectives, and performance metrics.
   - Examples:
     - Quality Assurance Teams: Can verify that the processes meet the company's quality standards.
     - Supply Chain Managers: Can verify the feasibility of logistical requirements, including sourcing materials and managing inventory.
     - HR and Training Personnel: Can confirm whether staffing and training needs are met.
5. **Clarify Ambiguities and Gaps**
   - During the review, identify any ambiguities or gaps in the operational requirements and work with the relevant personnel to resolve them.

- Example: If the technical requirements for a new system are unclear, the IT team should clarify the specifications needed for successful implementation.

- Scenario Simulation: Consider running simulations or "what-if" scenarios with the personnel to predict operational performance and identify any potential issues.

6. **Confirm Feasibility and Resources**
   - Verify that the operational requirements can be realistically achieved with the available resources, including:
     - Budget: Is the cost aligned with operational capabilities?
     - Time: Are timelines for implementation or operation realistic?
     - Equipment and Technology: Can the current technology or machinery meet the required standards?
   - The operations and finance teams should confirm that the necessary resources, both human and material, are available and allocated correctly

Self-check

Directions: Answer all the questions listed below.

Part I:Choose the correct answer for the following Questions

1. What is the primary purpose of a production drawing?

   A) To showcase marketing features of a product

   B) To provide detailed instructions for manufacturing a part

   C) To serve as a legal document

   D) To depict the product in a promotional brochure

2. Which type of drawing shows the overall dimensions and layout of an assembly?

A) Detail drawing B) Assembly drawing

C) Schematic drawing D) Isometric drawing

3. What type of production drawing focuses on a single part and provides detailed specifications?

A) Assembly drawing B) Detail drawing

C) Exploded view drawing D) Schematic drawing

4. Which type of drawing is often used to represent electrical circuits and their components?

A) Isometric drawing B) Schematic drawing

C) Assembly drawing D) Technical drawing

5. What type of drawing provides a three-dimensional representation of an object for better visualization?

A) Orthographic projection B) Isometric drawing

C) Section view drawing D) Detail drawing

6.What is the primary purpose of obtaining engineering drawings?

A) To improve communication among team members

B) To visualize and communicate design intent

C) To create marketing materials

D) To conduct market research

7. Which document provides detailed information about a product's materials, dimensions, and assembly instructions?

A) User manual B) Technical specification

C) Bill of materials D) Maintenance log

8. When reviewing technical manuals, what is the most critical section to consult for troubleshooting?

A) Warranty information B) Maintenance schedule

C) Troubleshooting guide D) Product specifications

9. What type of drawing typically shows the relationships between different parts of an assembly**?**

A) Schematic drawing B) Exploded view drawing

C) Sectional drawing D) Isometric drawing

10. Which document provides guidelines on how to maintain and operate a piece of equipment?

A) Technical specification B) User manual

C) Assembly drawing D) Design report.

Part II-Matching Column A with Column B

A **B**

A	B
____1. Provides detailed specifications for a single part.	A) Assembly Drawing
____2. Shows the overall dimensions and layout of an assembly.	B) Detail Drawing
____3. Represents electrical circuits and their components.	C) Schematic Drawing
____4. Provides a three-dimensional representation of an object.	D) Isometric Drawing
____5. Illustrates internal features of a part by cutting through it.	E) Section View Drawing
____6. Combines details and assembly instructions for production.	F) Manufacturing Drawing
____7. Depicts piping and equipment in a process system, including flow direction.	G) Piping and Instrumentation Diagram (P&ID)
____8. General term for any drawing that provides detailed information for manufacturing.	H) Technical Drawing

Part III: Answer the following terms with their correct descriptions

1. What is the difference between part drawing and assembly drawing?
2. Explain the Steps for Verifying Operational Requirements?
3. Explain the process of translating technical data into sketches or drawings. What are the important steps to ensure that specifications are accurately represented?
4. Draft Functions: Specify what the system should do, detailing each function's inputs, Processes, and outputs.
5. Operational Requirements: Outline the conditions necessary for the system to function, including hardware, software, network, and personnel needs

Unit two: Construction and Processing Data Calculation

This unit is developed to provide you the necessary information regarding the following content coverage and topics:-

- Data Collecting and calculating for the process
- Data Translating for sketch/drawing and specifications

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Collect and calculate Data for the process
- Translate data for use in sketch/drawing and specifications

2.1 Data Collecting and Calculating for the Process

All items in any field of inquiry constitute a "Universe" or "Population" When the population is small, all items of the population can be included in the inquiry this is known as a census inquiry. In such inquiry, highest accuracy is obtained Most population are large and it is impractical in terms of time, money and manpower to include every unit of the population in the study needs to select representative no of units from the population to make inferences about the entire population This process is called sampling part of the population selected for investigation is called a sample. A sample is a portion or a subgroup of a larger group called a population. Sometimes we want to include everyone; other times it is better to collect information from a sample

To calculate construction and processing data, you generally need to gather, analyze, and interpret various types of information relevant to a construction project or manufacturing process. These calculations typically involve:

1. Quantities of Materials (e.g., concrete, steel, or other building materials).
2. Labor Requirements (workforce estimates and hours).
3. Time Schedules (project duration, processing times, etc.).
4. Costs (material, labor, overhead).
5. Processing Efficiency (production rate, waste, etc.).
6. Quality Control (control charts, tolerances, inspections)

Control charts for variables many quality characteristics can be expressed in terms of a numerical measurement. For example, the diameter of a bearing could be measured with a micrometer and expressed in millimeters. A single measurable quality characteristic, such as a dimension, weight, or volume, is called a variable. Control charts for variables are used extensively. When dealing with a quality characteristic that is a variable, it is usually necessary to monitor both the mean value of the quality characteristic and its variability Control of the process average or mean quality level is usually done with the control chart for means, or the chart. Process variability can be monitored with either a control chart for the standard deviation, called the s chart, or a control chart for the range, called an R-chart. The R chart is more widely used. Usually, separate and R-charts are maintained for each quality characteristic of interest. X and R(orS) charts are among the most important and useful.

on-line statistical process monitoring and control techniques. Note that it is important to maintain control over both the process mean and process variability. Control charts for variables are statistical tools used in quality control processes to monitor and analyze the variation in data over time for continuous, measurable variables. These charts help identify whether a process is in statistical control (i.e., whether the variation is due to common causes) or if there are special causes of variation that require intervention.

Types of Control Charts for Variables:

1. X-bar and R Charts:
   - X-bar Chart: Monitors the process mean over time.
   - R Chart: Monitors the range of variability within each sample.
   - Used together, these charts allow tracking both the central tendency and the spread of a process.
2. X-bar and S Charts:
   - X-bar Chart: Again, this tracks the process mean.
   - S Chart: Tracks the standard deviation of each sample.
   - S charts are used when the sample size is relatively large (usually greater than 10), as they provide a better understanding of variability than the R chart.
3. Individual (I) and Moving Range (MR) Charts:
   - I Chart: Monitors individual data points over time.
   - MR Chart: Monitors the difference between consecutive data points.
   - These charts are useful when the sample size is 1, or when data is collected in a continuous stream rather than in groups.

Components of a Control Chart for Variables:

1. Data Points (Plotted Values):
   - Represent individual observations (in the I Chart), sample means (in the X-bar Chart), or ranges/standard deviations (in the R or S Charts).
2. Center Line (CL):
   - The center line represents the average (mean) value of the process over time. In the X-bar chart, it is the overall mean of all sample means.
3. Control Limits:
   - Upper Control Limit (UCL): The upper boundary indicating the highest value the process should produce under normal variation.
   - Lower Control Limit (LCL): The lower boundary indicating the lowest value the process should produce under normal variation.
   - The control limits are typically set at ±3 standard deviations (sigma) from the center line, covering 99.73% of all expected data points if the process is in control.

Step How to Create an X-bar and R Chart:

Step 1: Collect Data:

- Take samples (typically 3 to 5 observations per sample) from the process at regular intervals.
- Example: Suppose you collect 5 observations per sample and have 20 samples total.

Step 2: Calculate the Sample Statistics:

- X-bar (Sample Mean): For each sample, calculate the mean.
- Range (R): For each sample, subtract the smallest value from the largest.
    - R=Xmax−XminR

Step 3: Calculate the Overall Process Mean and Range:

- Overall Mean The average of all the sample means.

Step 4: Plot the Data:

- Plot the sample means on the X-bar chart and the ranges on the R chart. Add the center lines (the overall mean for the X-bar chart and the average range for the R chart) and the control limits.

Step 5: Interpret the Charts:

- In control: If all points are within control limits and show a random pattern, the process is in control.
- Out of control: If any point falls outside the control limits or if there is a non-random pattern (e.g., a trend or cyclical pattern), the process is out of control and requires investigation.

Benefits of Using Control Charts for Variables:

1. Detect Variability: Control charts for variables help identify both common cause (natural) variation and special cause (assignable) variation.
2. Monitor Process Stability: Control charts are essential in ensuring that a process remains stable over time and that any deviations from control are quickly addressed.
3. Improve Decision-Making: By providing a visual representation of process performance, control charts help quality managers make informed decisions about process adjustments.
4. Continuous Improvement: Using control charts regularly helps to establish a baseline for process performance and allows for continuous monitoring and improvement

The following illustrates the output of a production process. In figure below a both the mean μ and standard deviation σ are in control at their nominal values (say, μ_o and σ_o); consequently, most of the process output falls within the specification limits However, in Figure below b the mean has shifted to a value $\mu_1 > \mu_o$, resulting in a higher fraction of nonconforming product. In Figure below the process standard deviation has shifted to a value $\sigma_1 > \sigma_0$. This also results in higher process fallout, even though the process mean is still at the nominal value

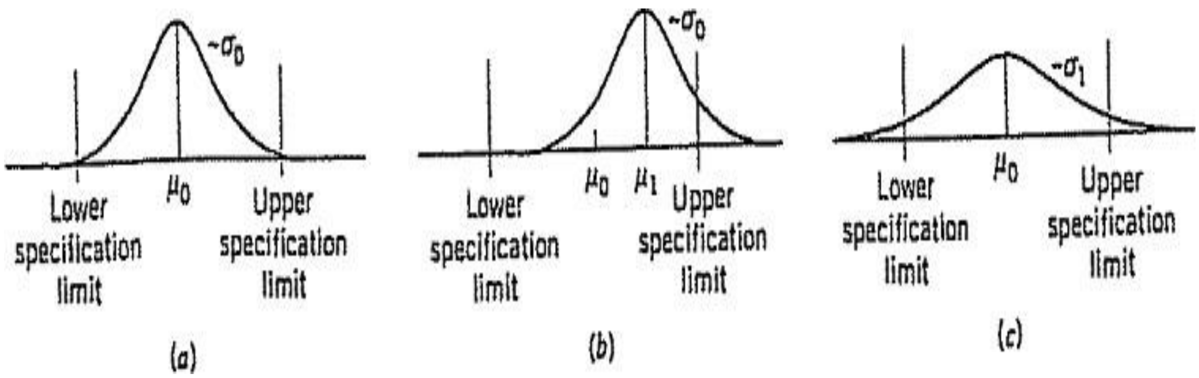


Figure 2.1 Mean and standard deviation

In the figure above the need for controlling both processes mean and process variability. (a)Mean and standard deviation at nominal levels. (b) Process mean $\mu_1 > \mu_0$, (c) Process standard deviation$\sigma_1 > \sigma_0$.

2.2 Data Translating for sketch/drawing and specifications

Translating data for use in sketches, drawings, and specifications is a critical step in the design and construction process. This phase involves converting raw data and technical information into clear and precise visual representations, as well as formal documentation that can be used for construction, manufacturing, or engineering purposes. Below are the key components and steps involved in this translation process.

Key Components of Translation:

1. Understanding the Data:
   - Begin by analyzing the raw data to understand the requirements, dimensions, and constraints of the project. This could include measurements, material properties, design requirements, and regulatory standards.
   - Types of data to consider:
     - Quantitative Data: Measurements, dimensions, weights, etc.
     - Qualitative Data: Material types, finish specifications, etc.
2. Creating Accurate Sketches and Drawings:
   - Types of Drawings:
     - Conceptual Drawings: Initial ideas and layouts that convey the overall vision.

   - ➢ Detailed Drawings: Comprehensive representations that include dimensions, materials, and construction methods.
   - ➢ Assembly Drawings: Illustrations that show how different components fit together.
- Software Tools: Utilize Computer-Aided Design (CAD) software such as AutoCAD, Revit, or Sketch up to create precise and scalable drawings.
- Scaling: Ensure that all drawings are accurately scaled, using appropriate units of measurement (e.g., metric or imperial).

3. Incorporating Specifications:
   - Technical Specifications: Document detailed descriptions of materials, workmanship, performance standards, and installation requirements.
   - Format: Use a standardized format for specifications, such as the Construction Specifications Institute (CSI) format, which organizes information into divisions (e.g., site work, concrete, finishes).
   - Material Properties: Include relevant data such as material types, grades, and compliance with industry standards.
4. Drafting Standards and Conventions:
   - Follow drafting standards and conventions to ensure consistency and clarity in the drawings. This includes:
     - ➢ Line Types: Different line styles (solid, dashed, dotted) to represent various elements (e.g., hidden lines, center lines).
     - ➢ Symbols: Standard symbols for electrical, plumbing, and mechanical components.
     - ➢ Dimensioning: Clearly indicate dimensions using arrows, numerical values, and appropriate units.
5. Labeling and Annotation:
   - Provide clear labels and annotations on drawings to ensure that all elements are easily understood. This may include:
     - ➢ Titles: Descriptive titles for each drawing.
     - ➢ Notes: Key instructions or information relevant to the drawing.
     - ➢ Revision History: A record of any changes made to the drawings and specifications.
6. Quality Control and Review:

- Conduct reviews and quality control checks to ensure that the translated data accurately reflects the original data and meets all project requirements.
- Peer Review: Involve team members or stakeholders in the review process to catch any discrepancies or errors.

7. Final Documentation:
   - Compile the finalized sketches, drawings, and specifications into a complete set of documents that can be used for construction or manufacturing.
   - Ensure that all documents are properly formatted, organized, and easily accessible for all stakeholders

Example Process:

1. Raw Data Collection:
   - Measurement data for a building foundation: Length = 20m, Width = 10m, Depth = 0.5m.
   - Material specifications: Concrete grade C25/30, rebar specifications.
2. Create Sketch:
   - Use CAD software to create a scaled drawing of the foundation, clearly indicating dimensions and the layout.
3. Incorporate Specifications:
   - Document material requirements:
     - ➢ Concrete: Grade C25/30, minimum compressive strength.
     - ➢ Reinforcement: Steel rebar diameter of 16mm, spacing of 15cm.
4. Drafting Standards:
   - Follow the architectural drafting standards for line types and dimensioning conventions.
5. Labeling and Annotation:
   - Add notes to specify curing time for the concrete and handling procedures for rebar.
6. Quality Control:
   - Review the drawing and specifications with project engineers and architects.
7. Final Compilation: high-quality manufacturing, and customer service and Data
   - Compile the drawings and specifications into a project manual for construction

Self-check

Direction: Answer all the questions below.

Part I:Choose the correct answer for the following questions

1. Which of the following is the most appropriate step when collecting and calculating all relevant data for a process?

   A) Analyzing data trends without verification

   B) Gathering all available data, even if irrelevant

C) Ensuring data accuracy, completeness, and relevance

D) Ignoring outliers and anomalies

2. Which of the following is the most important factor to consider when calculating construction and processing data?

A) Estimating data based on previous projects without verification

B) Ensuring the use of accurate measurements and precise calculations

C) Using approximate values to speed up the process

D) Relying on manual calculations instead of software tools

3. Which of the following best describes the goal of semantic translation?

A) Translating word-for-word without regard for context

B) Maintaining the meaning of the original text while adapting it to the target language's natural phrasing

C) Prioritizing the cultural context over the actual meaning of the words

D) Rewriting the text completely to fit the style of the target audience

4. When translating data for use in sketches, drawings, and specifications, which of the following is the most important consideration?

A) Using the most complex design software available

B) Ensuring the data is presented in a clear, precise, and standardized format

C) Ignoring industry standards to encourage creativity

D) Prioritizing speed over accuracy

5. What is the primary focus of semantic translation?

A) Translating text word-for-word regardless of context.

B) Preserving the original meaning, context, and cultural nuances in the translated text.

C) Using automated translation tools without human intervention.

D) Translating only technical jargon and terminology.

Part II: Write True if the statement is correct or False if not correct.

1. It is important to maintain accuracy when translating data into sketches and specifications.
2. Standardization of data formats is not necessary when creating technical drawings.
3. Translating data for use in sketches and drawings involves converting raw data into visual representations.

4. Speed is more important than precision when creating specifications from data.
5. All data, even irrelevant or inaccurate, should be included in sketches and specification

Part III: Matching column A with Column B with their correct descriptions

A	B
____ 1.Ensuring the information follows industry guidelines and is consistently	A) Data Interpretation formatted.
.____2.converting raw data into a graphical form that can be used in sketches and .	
.____ 3.Ensuring that the data used in drawings and specifications is precise and free of errors	B) Standardization designs
____4. Analyzing data to extract relevant information for designing specifications	C) Accuracy
	D) Visualization

Part IV: Explain the Following Question

1. What are the key considerations when translating data for use in sketches, drawings, and specifications?
2. Explain about Semantic translation?
3. Explain the key components and steps involved in this translation process
4. When dealing with specialized texts, such as technical or legal documents, collaborating with experts in the field ensures that the translation accurately reflects the necessary terminology and context

Unit three: Preliminary Sketch/Drawing/ Specifications

This unit is developed to provide you the necessary information regarding the following content coverage and topics:-

- Basic components, assemblies and fasteners Selection
- Component and Materials Selection.
- Codes of Sketch/Drawing/Specification.
- Approving the preliminary sketch/drawing/specification.

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Select appropriate basic components, assemblies and fasteners.
- Choose the required components and/or materials.
- Apply appropriate and relevant codes to the sketch/drawing/specification.
- Approve the preliminary sketch/drawing/specification.

3.1 Basic components, assemblies and fasteners Selection

To select components we have to consider a listing of all of the raw materials, parts, subassemblies, and assemblies needed to produce one unit of a product. So to prepare and select components, assemblies and fasteners we should arranged using bill of materials. Each finished product has its own bill of materials. Product structure tree: Visual depiction of the requirements in a bill of materials, where all components are listed by levels. Basically, a bill of material (BOM) is a complete list of the components making up an object or assembly.

Product Structure Diagram The product structure diagram is a graphical representation of the relationship between the various levels of the productive system.

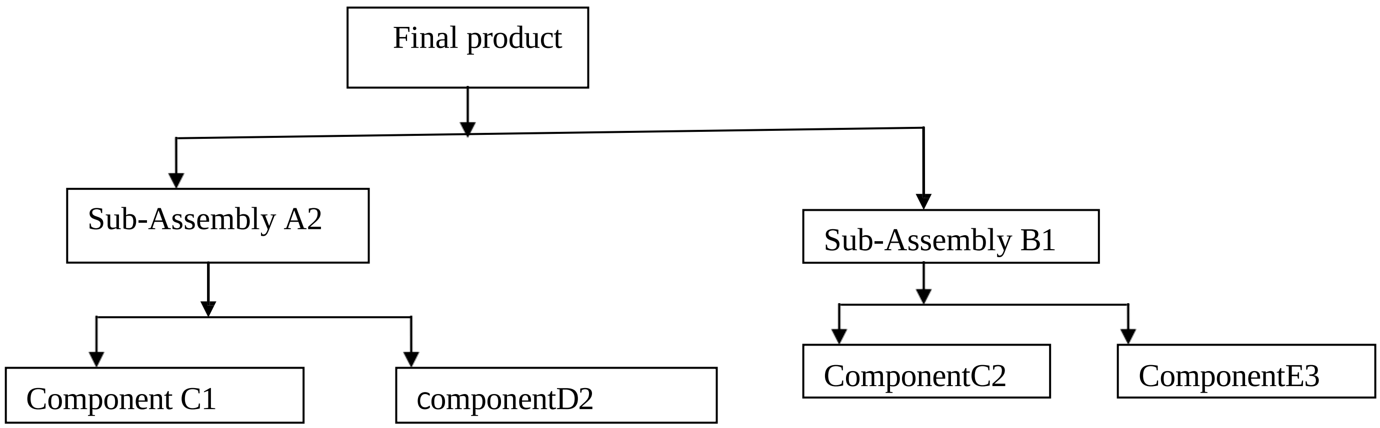


Figure 3.1 Product structure diagrams

Selecting the right basic components, assemblies, and fasteners is critical to the success of any construction or manufacturing project. This process involves understanding the project requirements, the properties of the materials, and the operational environment.

3.1.1 The key considerations and steps for making appropriate selections.

1. Understanding Project Requirements

Before selecting components, it is essential to understand the specific needs of the project. This includes:

- Load Requirements: Determine the types of loads (static, dynamic, tensile, compressive) that the components will bear.
- Functionality: Identify the functional requirements of the assembly (e.g., support, connection, motion).
- Environmental Conditions: Consider the environment in which the components will operate, including factors like temperature, humidity, corrosion potential, and exposure to chemicals.

2. Selecting Basic Components

Basic components can include beams, columns, plates, and other structural elements. When selecting these components:

- Material Properties: Choose materials based on their mechanical properties (tensile strength, ductility, hardness, etc.), weight, cost, and availability. Common materials include:
    - Steel: High strength, used in structural applications.

- Aluminum: Lightweight, good corrosion resistance.
- Concrete: Good compressive strength, used in foundations and structural elements.
- Wood: Traditional material, good for lightweight structures.

- Dimensions and Specifications: Ensure the selected components meet the required dimensions and specifications, such as length, width, thickness, and tolerances.
- Standards and Codes: Verify that the components comply with relevant industry standards and building codes (e.g., ASTM, AISC, ACI).

3. Selecting Assemblies

Assemblies consist of multiple components that work together. When selecting assemblies:

- Pre-fabricated Assemblies: Consider using pre-fabricated assemblies (like trusses, panels, or modular units) to save time and reduce labor costs.
- Fit and Compatibility: Ensure that all components within the assembly fit together correctly and function as intended.
- Ease of Assembly: Evaluate how easy it is to assemble the components on-site, considering labor skills and available tools.

4. Selecting Fasteners

Fasteners are critical for joining components. Selecting appropriate fasteners involves:

- Type of Fastener: Choose the right type of fastener based on the application:
  - Bolts: Used for high-strength connections, available in various grades.
  - Nuts: Must match the bolt type and grade.
  - Screws: Suitable for lighter applications and can provide better holding power in wood or sheet materials.
  - Rivets: Permanent fastening method, commonly used in structural applications.
  - Welds: Used to create permanent joints in metals.
- Material and Coating: Select fasteners made from materials that match the components and resist corrosion (e.g., stainless steel, galvanized steel).
- Size and Strength: Determine the size and strength of the fasteners based on the loads they will bear. Use fastener tables or calculations to ensure they are adequate for the application.
- Thread Type: Choose between coarse and fine threads based on the application. Coarse threads are better for quick assembly, while fine threads provide better tension control.

5. Consideration of Load and Connection Types

- Shear, Tensile, and Compressive Loads: Understand the types of loads that the connections will be subjected to, which will influence the choice of fasteners and joint designs.
- Connection Types: Decide on the connection type (e.g., bolted, welded, riveted) based on the load requirements, ease of assembly, and disassembly if needed.

6. Quality and Reliability

- Quality Assurance: Ensure that all components, assemblies, and fasteners come from reputable manufacturers and meet quality standards.
- Testing and Certification: Where applicable, use components that have been tested and certified for the intended use (e.g., load testing for structural components).

3.1.2Selection Process

1. Identify Requirements:
   - Load: The structure will support a roof and upper floors.
   - Material: Use structural steel for strength and durability.
2. Select Basic Components:
   - Columns: Choose H-beams based on load-bearing capacity.
   - Beams: Select I-beams for floor supports, ensuring they meet span requirements
3. Select Assemblies:
   - Trusses: Consider using pre-fabricated trusses for the roof to speed up construction.
4. Select Fasteners:
   - Bolts: Use high-strength bolts for connections between beams and columns.
   - Nuts: Match with the selected bolts, ensuring they are lock nuts for safety.
5. Quality Assurance:
   - Source materials from certified suppliers and ensure they meet industry stand

3.2 Required Component and Materials Selection

When selecting the required components and materials for a project, whether it's engineering, construction, manufacturing, or electronics, there are several key factors to consider to ensure that the project is efficient, cost-effective, and meets all necessary standards

3.2.1 Material Selection

- Metals: For strength, conductivity, or heat resistance (e.g., aluminum, stainless steel, copper, titanium).

- Plastics and Polymers: For lightweight, non-corrosive, or insulating purposes (e.g., PVC, polyethylene).
- Composites: For lightweight, high-strength, or tailored performance (e.g., carbon fiber, fiberglass).
- Ceramics and Glass: For heat resistance, insulation, or optical clarity (e.g., borosilicate glass, ceramic insulators).
- Textiles and Fabrics: For flexibility, durability, or specific environmental needs (e.g., Kevlar, nylon).

3.2.2 Component Selection (for Electronics, Machinery, etc.)

- Electrical Components: Ensure components such as resistors, capacitors, transistors, or ICs meet voltage, current, and power ratings.
- Mechanical Components: Select fasteners, bearings, gears, and other moving parts based on load, wear, and lubrication needs.
- Sensors and Actuators: Choose based on sensitivity, accuracy, and required output for feedback systems.
- Prototyping and Testing Components: Select components that allow for testing, debugging, and proof-of-concept before final design

3.3 Codes of Sketch/Drawing/Specifications

Applying codes and standards to sketches, drawings, and specifications is essential in ensuring that projects comply with legal, safety, and performance requirements. This process involves integrating various codes into the design documents to guide construction, manufacturing, and engineering practices. Below are key aspects to consider when applying codes:

1. Understanding Applicable Codes and Standards

Before you begin applying codes, it's important to identify the relevant codes and standards that govern your project. These can include:

- Building Codes: Regulations set by local, state, or national authorities that govern building safety, structural integrity, fire safety, and accessibility (e.g., International Building Code (IBC), National Fire Protection Association (NFPA) codes).
- Industry Standards: Guidelines established by organizations that define best practices, material specifications, and performance criteria (e.g., American Society for Testing and Materials (ASTM), American National Standards Institute (ANSI)).

- Environmental Regulations: Compliance with regulations related to environmental impact and sustainability (e.g., Leadership in Energy and Environmental Design,(LEED) certification).
- Occupational Safety and Health Administration (OSHA): Standards for workplace safety during construction and manufacturing.

2. Integrating Codes into Sketches and Drawings

When creating sketches and drawings, follow these guidelines to apply codes effectively:

- Use Standardized Formats: Adhere to recognized drawing standards, such as those from the American National Standards Institute (ANSI) or the International Organization for Standardization (ISO), to ensure clarity and consistency.
- Include Code References: Clearly annotate drawings with references to applicable codes. This could be in the title block or as a note on the drawing itself (e.g., "Designed in accordance with IBC 2021").
- Indicate Compliance: Use symbols or notes to indicate areas of compliance with specific codes, such as fire-rated walls, accessible entries, or structural loading requirements.
- Dimensioning and Tolerances: Ensure that dimensions are clearly marked according to relevant standards, with tolerances specified as needed to comply with manufacturing and construction practices.

3. Writing Specifications with Code Compliance

Specifications serve as the written guidelines for project execution. When drafting specifications:

- Cite Relevant Codes: Include references to applicable codes within the specifications. For instance, “All work shall comply with the latest edition of the International Building Code (IBC) and local amendments.”
- Material Specifications: Ensure that material selections meet industry standards and codes. For example, if specifying concrete, refer to relevant ASTM standards (e.g., ASTM C150 for Portland cement).
- Quality Control Procedures: Define procedures for quality control that align with code requirements, such as inspection processes, testing methods, and certification of materials.
- Safety and Accessibility Standards: Include specifications for safety features (e.g., guardrails, handrails) and accessibility standards (e.g., Accessible Design,(ADA) compliance) as mandated by relevant codes.

4. Compliance Checks and Reviews

Conduct compliance checks and reviews to ensure all drawings and specifications adhere to applicable codes:

- Peer Review: Involve team members or external consultants to review drawings and specifications for code compliance.
- Regulatory Review: Submit drawings and specifications to local building authorities for review and approval to ensure they meet all necessary codes.
- Quality Assurance Protocols: Implement quality assurance protocols to regularly check that ongoing construction or manufacturing adheres to the specifications and codes.

5. Documentation and Record Keeping

Maintain thorough documentation to demonstrate compliance with codes and standards throughout the project lifecycle:

- Code Compliance Certificates: Keep records of any compliance certificates or approvals obtained from regulatory bodies.
- Change Orders: Document any changes made during construction that may affect compliance with codes, along with approvals from the relevant authorities.
- Inspection Reports: Maintain records of inspections and tests conducted to ensure ongoing compliance with codes.

Some of the codes or specifications put in part drawings are:-

1. Shape description This refers to the selection of number of views to describe the shape of the part. The part maybe drawn in either pictorial or orthographic projection; the latter being used more frequently. Sectional views, auxiliary views and enlarged detailed views may be added to the drawing in order to provide a clear image of the part.

2. Size description Size and location of the shape features are shown by proper dimensioning. The manufacturing process will influence the selection of some dimensions, such as tolerances, etc.

3. Specifications This includes special notes, material, heat treatment, finish, general tolerances and number required. All this information is mostly located near the title block.

4. Additional information Such as drawing number, scale, method of projection, date, names of the parts, the daughter's name, etc., come under additional information which is included in the title block

Figure 3.2Sketching and description

3.4 Preliminary Sketch/Drawing/Specification Approval

The drawings made by someone should be approved by another person who is more expertise on that area. This reduces mistakes in drawing before going to be manufactured which may be result in mistakes in manufacturing wastage of materials, lobar force and wastage of time.

1. Purpose

- To establish a formal process for the approval of preliminary sketches, drawings, and specifications necessary for project development.

2. Scope

- This process applies to all design documents submitted by architects, engineers, or designers involved in the project.

3. Submission Requirements

- Preliminary sketches, drawings, or specifications must be submitted to the designated authority for review.
- Each submission should include:
  - A cover letter detailing the purpose of the submission.
  - A checklist confirming all required components are included.
  - A proposed timeline for the review process.

4. Review Process

- The designated authority will review the submissions within a specified timeframe (e.g., 10 business days).
- The review will assess:
  - Compliance with project requirements..
  - Alignment with client needs and expectations.

5. Approval Criteria

- Documents will be approved based on:
  - Completeness and clarity of information.
  - Technical accuracy.
  - Feasibility within project constraints (budget, timeline, resources).

6. Feedback and Revisions

- If changes are necessary, the authority will provide written feedback detailing required revisions.
- The submitting party must address the feedback and resubmit the revised documents.

7. Final Approval

- Once revisions are made satisfactorily, the authority will provide formal approval, allowing the project to proceed to the next phase.

Self-check

Direction: Answer all the questions below.

Part I: Choose the correct answer for the following Questions

1. When selecting appropriate basic components, assemblies, and fasteners for a project, which factor is most important to consider?

   A) Choosing the cheapest materials to minimize costs

   B) Selecting components and fasteners based solely on availability

   C) Ensuring compatibility with design specifications, load requirements, and material properties

   D) Prioritizing aesthetic appearance over functional performance

2. Which is the most critical factor to consider when selecting where to source required components and/or materials for a project?

   A) Choosing the supplier with the fastest delivery, regardless of quality

   B) Ensuring the components and materials meet the project's technical specifications and standards

   C) Selecting the most expensive materials to guarantee the highest quality

   D) Sourcing components only from local suppliers to reduce transportation cost

3. What is the most important factor to consider when approving a preliminary sketch, drawing, or specification?

A) The aesthetic appeal of the design without considering functionality

B) Compliance with project requirements, codes, and stakeholder expectations

C) The speed at which the drawing was created

D) The number of revisions made during the drafting process

4. Which of the following is the first step in preparing a preliminary sketch, drawing, or specification?

A) Finalizing the design with all details included

B) Gathering and analyzing all relevant project requirements and constraints

C) Choosing the colors and materials for the final design

D) presenting the draft to stakeholders for immediate feedback

5. What is the most critical action to take before approving a preliminary sketch, drawing, or specification?

A) Ensure that the drawing has been completed in the shortest time possible

B) Review the design for compliance with relevant codes, standards, and stakeholder requirements

C) Confirm that the design uses the most expensive materials available

D) Seek approval from the design team only, without consulting other stakeholders

Part II: Matching column A with column B with their correct descriptions

A	B
1. Regulations that dictate how land can be used, including building	A. Building Code height, density, and purpose
2. Guidelines that ensure designs adhere to safety practices and minimize hazards for users	B. Zoning Code. C. Safety Standards safety, and welfare of occupants
3. Codes that establish minimum construction requirements for health	D. Industry Standards materials and processes within a specific industry
4. Specifications that provide best practices and benchmarks for	

Part I: Write True if the statement is correct or False if not.

1. The approval of a preliminary sketch, drawing, or specification should prioritize aesthetics over functionality.
2. Stakeholder feedback is an important consideration during the approval process.
3. It is acceptable to approve a preliminary design that does not comply with local building codes.
4. The clarity and accuracy of a preliminary sketch are critical for its approval.
5. Once a preliminary sketch is approved, no further changes can be made.

.Part IV: Explain the following question

1. What are the key factors to consider when approving a preliminary sketch, drawing, or specification?
2. What is the most critical action to take before approving a preliminary sketch, drawing, or specification?
3. Describe the key factors to consider when selecting components or materials for a new product design. Include at least three specific criteria in your response.
4. How to Integrating Codes into Sketches and Drawings?
5. Codes of Sketch/Drawing/Specifications refers to the practice then how to works established standards and guidelines when creating technical drawings?

Unit Four: Mechanical System Planning

This unit is developed to provide you the necessary information regarding the following content coverage and topics:-

- Parts of the mechanical system
- Composing the parts to a mechanical system.
- NC And CNC Machines Programming
- Simulating and evaluating the function.

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Identify parts of the mechanical system.
- Assemble the parts into a complete mechanical system
- Make necessary programming of NC and CNC machines
- Simulate and evaluate the system functionality

4.1 Parts of Mechanical System

A mechanical system consists of interconnected parts designed to perform a specific function, typically involving the conversion of energy or motion. It is to provide a comprehensive overview of the components that make up a mechanical system, facilitating understanding and effective communication among team members.

4.1.1 Common Parts of a Mechanical System

a. Framework/Structure

- Provides support and shape to the system.
- Materials used may include metals, plastics, or composites.

b. Actuators

- Devices that convert energy into motion.
- Types include hydraulic, pneumatic, electric motors, and solenoids.

c. Sensors

- Components that detect physical properties (e.g., temperature, pressure, motion).
- Examples include thermocouples, pressure sensors, and position encoders.

d. Gears and Transmissions

- Mechanisms that transmit power and motion between parts.
- Includes gears, belts, chains, and couplings.

e. Bearings

- Reduce friction between moving parts and support rotational motion.
- Types include ball bearings, roller bearings, and sleeve bearings.

f. Fasteners

- Connect different parts of the system.
- Includes bolts, screws, nuts, and rivets.

g. Power Sources

- Provide energy to the system, such as batteries, engines, or power grids.

h. Control Systems

- Manage and regulate the operation of the mechanical system.
- Includes microcontrollers, programmable logic controllers (PLCs), and user interfaces.

4.1. 2. Identification Techniques

Visual Inspection

- Examine the mechanical system for visible parts and components.

Documentation Review

- Refer to design specifications, diagrams, and manuals to identify parts.

Component Tagging

- Label parts for easy identification during assembly, maintenance, and troubleshooting.

4.1.3. Importance of Identifying Parts

- Facilitates effective communication among team members.
- Essential for troubleshooting and maintenance.
- Supports efficient design and manufacturing processes.

Mechanical Systems or Devices are designed to transmit power and accomplish specific patterns of motion. Some of the Mechanical Components are Gears, Bearings, Shafts, Keys, Couplings, Seals, etc.

A mechanical system manages to accomplish a task that involves forces and movement.

Mechanical components are components used to transmit power and accomplish specific patterns of motion some of the mechanical components are Motors, Gears, Bearings, Shafts, Keys, Couplings, Seals, etc.

A) **Electric Motor :**it is an electro-mechanical device that converts electrical energy to mechanical energy. Mechanical energy used to e.g. rotate pump impeller, fan, blower, Drive compressors, and Lift materials. Most Industries uses 70% of electrical load Motors

There are three types of Motor Loads

Table 4.1 Types of Motor Loads

Motor loads	Description	Examples
Constant torque loads	Out put power varies but torque is constant	Conveyors, rotary kilns, constant-displacement pumps
Variable torque loads	Torque varies with square of operation speed	Centrifugal pumps, fans
Constant power loads	Torque changes inversely with speed	Machine tools

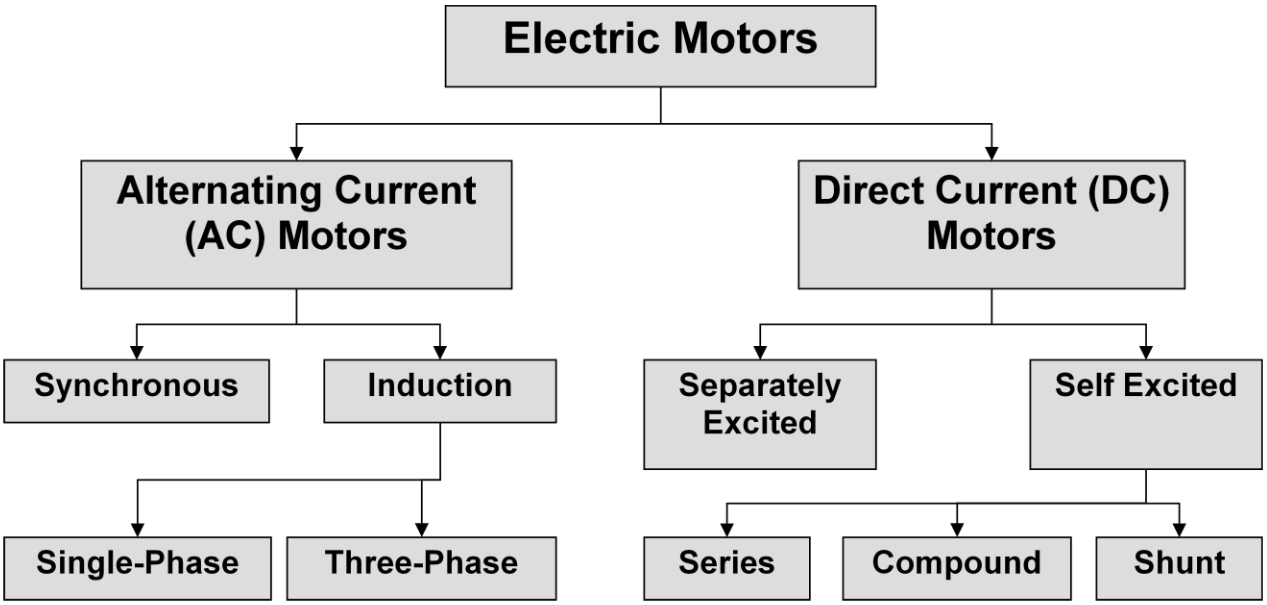


Figure 4.1.Classification of Motors

The motor can be connected to the load through a set of gears. The gears have teeth ratio and can be treated as torque transformers. They are used to amplify the torque on load side at lower speed compared to the motor speed. The motors are designed to run at high speeds because it has been found that the higher the speed, the lower is the volume and size of the motor.

Table 4.2Electric Motor power rates

Motor Size	Service Entrance Amperage & Wiring	Voltage	Phase
1/3hp or less	30A; 2-wire	120 V	Single
1/3hp-1½ hp	30A; 3-wire	120-240V	Single
1½hp-5hp	60A; 3-wire	120-240V	Single
5hp-7½hp	100A; 3-wire	120-240V	Single
Over7hp	Over100A;4-wire	277-480V	Three

B) Gear: it is a wheel with teeth that mesh together with other gears. Gears change the speed, torque (rot. force) and direction of rotating axles.

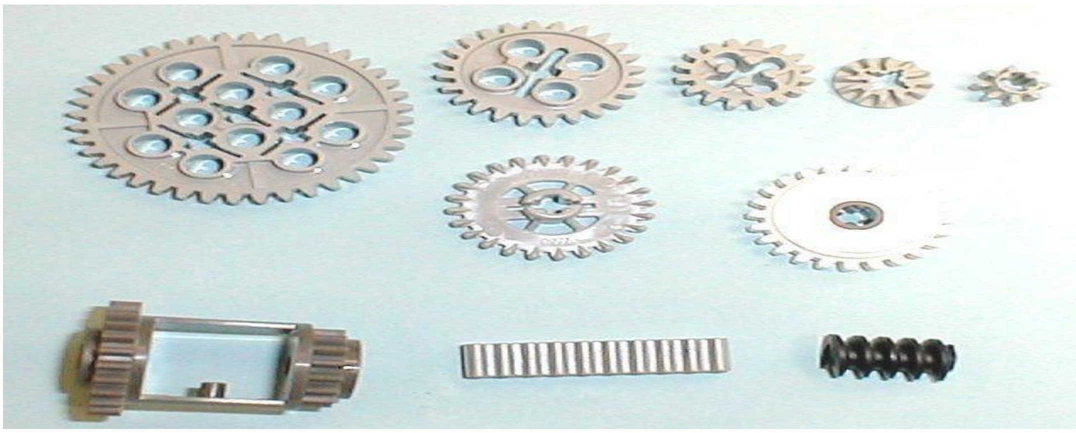


Figure 4.2.Types of Gears

The gear ratio is the ratio of the number of teeth on one gear to the number of teeth on the othergear.

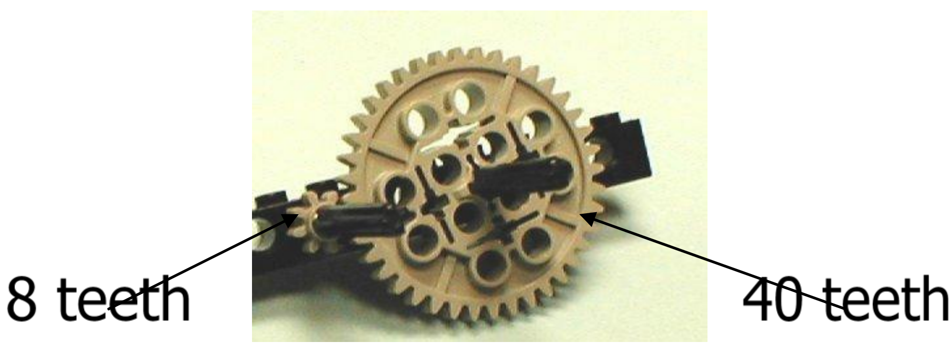


Figure 4.3.Gear Ratio

Gear ratio =40 to 8 or, simplifying, 5 to 1That means it takes 5 revolutions ofthesmaller gearto get 1 revolution of the larger gear. Try it! The gear ratio tells you the change in speed and torque of the rotating axles. If it takes 5 turns of the 8 tooth gear for every 1 turn of the 40 tooth gear, that means the 40 tooth gear will rotate 5 times slower than the 8 tooth gear. But, it also means the 40 tooth gear's axle has 5 times the **torque** (rotational force) as the 8 tooth gear's axle.

C) **Fasteners:** A machine element used for holding or joining two or more parts of a machine or structure is known as a **fastener**. The process of joining the parts is called **fastening.**

The fasteners are of two types**:** Permanent and Removable(Temporary)

Riveting and welding processes are used for fastening permanently. Screwed fasteners such as bolts, studs and nuts in combination, machine screws, set screws, etc., and keys, cotters, couplings, etc. ,are used for fastening components that require frequent assembly and disassembly Screwed fasteners occupy the most prominent place among the removable fasteners.

In general, screwed fasteners are used to hold parts together, to adjust parts with reference to each other and to transmit power.

4.2 Composition of parts to mechanical system

To outline the processes and considerations involved in assembling individual components into a functional mechanical system. Mechanical systems are composed of various interconnected parts that work together to perform specific functions. Proper composition is crucial for system efficiency, reliability, and performance.

1. Assembly Process

a. Preparation

- Gather all necessary components, tools, and equipment.
- Review design specifications and assembly instructions.

b. Component Inspection

- Inspect parts for defects or damages.
- Ensure compatibility of components (e.g., dimensions, materials).

c. Sequencing

- Determine the order of assembly based on the design and accessibility.
- Follow logical steps to avoid complications during the assembly process.

2. Joining Methods

a. Mechanical Fastening

- Use bolts, screws, nuts, and rivets to connect components.

- Ensure proper torque and alignment to maintain structural integrity.

b. Welding

- Join parts through fusion using techniques like MIG, TIG, or arc welding.
- Ensure appropriate preparation and safety measures are taken.

c. Adhesives

- Utilize bonding agents to assemble components where mechanical fasteners are not suitable.
- Select adhesives based on the materials and required strength.

d. Interference Fits and Housings

- Create tight connections between parts using precision machining.
- Design housings that allow for secure placement of internal components.

3. Alignment and Calibration

a. Alignment

- Ensure all components are properly aligned to prevent excessive wear and ensure smooth operation.
- Use alignment tools such as levels, lasers, or dial indicators.

b. Calibration

- Adjust components for optimal performance.
- Set parameters for sensors and actuators to ensure accurate readings and responses.

4. Testing and Validation

- Conduct functional tests to ensure the assembled system operates as intended.
- Use diagnostic tools to identify any issues that may arise during operation

By composing motors bearing ⟶ Shaft ⟶ Key ⟶ gear ⟶ out put

Based on the torque out put the number of gears and shafts can be increased or decreased. Basically the speed get from the motor is high speed then the high speed will be changed to torque by using gear or pulley system.

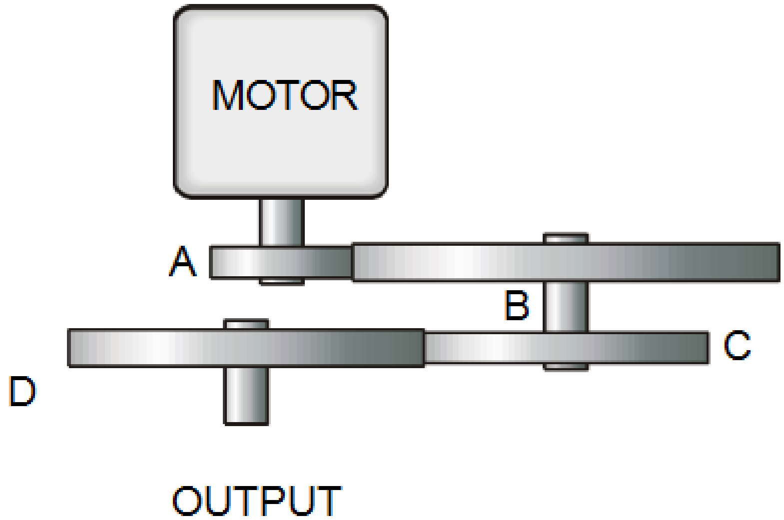


Figure 4.3.Motor Compositions

4.3 NC and CNC Machines Programming

Programmers, a course related to manual programming provides an excellent platform to address some important CNC issues—issues that form the foundation of a person's understanding of CNC. Features such as program zero, coordinate systems, absolute versus incremental, motion types, the various compensation types and special programming features are best presented during a discussion of manual programming. Trying to present these features to entry-level students while they're trying to learn a CAM system will confuse them and have limited success. Starting at CAM system level without understanding the basics of manual programming is like learning to use an electronic calculator without understanding basic arithmetic. Entry level CNC setup people and operators must eventually understand at least some manual programming techniques if they will be expected to edit programs at the machine during a program's verification. While not all companies expect this, the more setup people or operators understand about manual programming, the better they can perform. But if you don't know manual programming, how can you be sure your CAM system is outputting programs in the most efficient manner? The first step to making any improvement knows what's possible.

To manufacture complex curved geometries in 2D or 3D was extremely expensive by mechanical means (which usually would require complex jigs to control the cutter motions) Machining components with repeatable accuracy. using Unmanned machining operations by Part program with a computer program to specify Which tool should be loaded on the machine spindle, What are the cutting conditions (speed, feed, coolant ON/OFF etc), The start point and end point of a motion segment, how to move the tool with respect to the machine.

Manual Programming often questioned about the scope of this column. The most common question is "Why do you continue to discuss manual programming techniques when almost all companies are using CAM systems?" Aside from the fact that other columnists are addressing issues related to computer integrated manufacturing, I believe that a firm understanding of manual programming is of paramount importance to all CNC people. It is important not only for short term issues and specific applications, but for the long haul in every CNC environment—from a person's first acquaintance with CNC through their attainment of expertstatus.Forentry-level CNC

4.3.1 Making Necessary Programming of CNC

Programming is to outline the steps required to create effective and accurate CNC programs for machining parts.

1. Overview of CNC Programming

CNC programming involves writing code that instructs the CNC machine on how to perform machining tasks. This includes specifying the movements, tool changes, and other operations necessary to manufacture a part.

2. Programming Languages

a. G-Code

- The most commonly used language for CNC programming.
- Consists of commands that control movement, speed, and other machine functions.

b. M-Code

- Used for miscellaneous functions such as tool changes, spindle control, and coolant activation.

3. Preparation for Programming

a. Design Review

- Review the CAD (Computer-Aided Design) model and technical drawings of the part to be manufactured.
- Identify key features, dimensions, and tolerances.

b. Tool Selection

- Choose the appropriate cutting tools based on material and machining requirements.
- Determine tool specifications, including diameter, length, and type.

4. CNC Programming Steps

a. Define the Coordinate System

- Establish the work coordinate system (WCS) and tool coordinate system (TCS).
- Specify the origin point and orientation for machining operations.

b. Write the CNC Program

- Begin with a program header that includes basic information (e.g., program name, date).
- Use G-code to define movements (e.g., G00 for rapid positioning, G01 for linear interpolation).
- Incorporate tool changes, feed rates, spindle speeds, and coolant commands using M-code.

c. Include Safety and Control Codes

- Add codes for safety measures, such as limiting travel and activating emergency stops.
- Ensure the program includes checks for tool wear and machine conditions.

5. Simulation and Verification

a. Use CNC Simulation Software

- Simulate the CNC program to visualize tool paths and operations.
- Identify potential collisions, errors, or inefficiencies in the program.

b. Verify Program Accuracy

- Cross-check program code against the original design specifications.
- Make necessary adjustments based on simulation results.

6. Uploading and Testing the Program

Uploading to CNC Machine

- Transfer the verified CNC program to the machine control unit.
- Ensure proper connectivity and file format compatibility.

4.4 Simulating and Evaluating the Function

1. Define the Function

Start by specifying the mathematical function f(x). This function can be anything from a simple linear equation to a complex non-linear system.

For example, let's say we have the function:

f(x)=x2+2x+1f(x) = x^2 + 2x + 1f(x)=x2+2x+1

2. Choose the Input Parameters

Decide on the values for xxx or the range of xxx values you want to simulate. For example, you might want to evaluate the function for several values in a specific interval, such as x=0,1,2,3x = 0, 1, 2, 3x=0,1,2,3.

3. Simulate the Function

Compute the output values of the function for the chosen inputs. This can be done manually or through a programming tool (like Python, MATLAB, or Excel). For example, if we are using Python, the code would look something like:

For x=0,1,2,3x = 0, 1, 2, 3x=0,1,2,3, the outputs would be:

f(0)=1,f(1)=4,f(2)=9,f(3)=16f(0) = 1, \quad f(1) = 4, \quad f(2) = 9, \quad f(3) = 16f(0)=1,f(1)=4,f(2)=9,f(3)=16

4. Evaluate the Results

Assess the results by looking at the function behavior. This might include analyzing how the function changes with respect to xxx, finding trends or patterns, and determining the function's minimum, maximum, or other key features.

5. Visualization (Optional)

Plot the results to better understand the function's behavior visually. In Python, you could use mat plot lib:

6. Advanced Simulations

For more complex functions or systems (like differential equations, stochastic simulations, etc.), you may need advanced simulation techniques, including:

- Numerical methods (Euler's method, Runge- Kutta, etc.) for solving differential equations.
- Monte Carlo simulations for stochastic models.
- Agent-based modeling for more sophisticated simulations of complex system

Self-check

Direction: Answer all the questions below.

Part I:Choose the correct answer for the following Questions

1. Which of the following is the most important initial step in planning a mechanical system?

A) Selecting the materials for the components

B) defining the system's purpose and requirements

C) Choosing the type of fasteners to be used

D) conducting a stress analysis on the components

2., which of the following is most critical to ensure proper system function?

A) Selecting parts with the lowest cost

B) Ensuring compatibility and proper fit between components

C) Choosing the heaviest materials for durability

D) Minimizing the number of moving parts

3. Which of the following components is ***NOT*** typically considered part of a mechanical system?

A) Gears B) Levers

C) Electrical circuits D) Bearings

4. What is the primary consideration when composing the parts of a mechanical system?

A) Aesthetics and visual appeal of the components

B) ensuring that all parts function together harmoniously and meet design specifications

C) Selecting the most expensive materials available

D)when composing the parts of a mechanical system

5. Which of the following is the most important step when programming NC and CNC machines?

A) Writing code without verifying tool-path accuracy

B) selecting the appropriate tools and materials for the job

C) ensuring that the program is optimized for efficiency and accuracy

D) ignoring safety protocols to speed up the programming process

Part II: Match the following programming concepts with their correct definitions.

A	B
1. A process of simulating the machine's operations before actual machining.	A. G-Code
2. Instructions that guide the machine's movement and operations.	B. M-Code
3. The programming language used for CNC machines.	C. Tool Path
4. The sequence and strategy used for the cutting tool to follow during machining.	D. Post-Processing
5. Commands that control specific machine functions, such as turning on/off coolant or spindle.	E. Simulation
6. A preliminary test run without material to verify the programming and tool paths	F. Dry Run.
7. Software used to create the part design and convert it into machine-readable instructions.	G. CAD/CAM Software
8. The process of choosing appropriate tools for machining based on material and operation type.	H. Tool Selection

Part III: Write True if the statement is correct or False if not.

1. Simulating a function involves running a model or algorithm to predict the output based on inputs, while evaluating a function refers to calculating the function's output for specific input values.
2. CNC machines use pre-programmed computer software to automate control over machining tools, whereas NC machines rely on manually prepared punched tapes or magnetic tapes for operation.
3. When composing parts of a mechanical system, selecting components based solely on their individual performance is sufficient for ensuring the overall system's functionality.
4. In a mechanical system, each component must be designed to fit and function properly with other parts to ensure the system operates efficiently.
5. Making necessary programming of CNC" can be interpreted as needing to program CNC machines to operate them correctly

Part IV: Explain the following question

1. Why is it important to ensure compatibility when composing the parts of a mechanical system?
2. What are the key steps involved in making the necessary programming for NC and CNC machines?
3. What are the classification of electric motors?

Operation Sheet

Operation Title: Part Programming

Purpose: To write part programming for different parts and simulate it to check its functionality.

Equipment Tools and Materials:

- Desktop computer
- Solid works or Master CAM software
- CNC machine tools

Quality Criteria: Assured performing of all the activities according to the procedures.

Part programming and machine control

1. Absolute positioning. In this mode, the desired target position of the tool for a particular move is given relative to the origin point of the program.
2. Incremental positioning. In this mode, the next target position for the tool is given relative to the current tool position

Preparatory function codes

Codes	**Function**
G00	Rapid traverse
G01	Linear interpolation
G02	Circular interpolation, CW
G03	Circular interpolation, CCW
G04	Dwell
G08	Acceleration
G09	Deceleration
G17	X-Y Plane
G18	Z-X Plane
G19	Y-Z Plane
G20	Inch Units(G70)
G21	Metric Units (G71)
G40	Cutter compensation –cancel
G41	Cutter compensation–left
G42	Cutter compensation-right
G70	Inch format
G71	Metric format
G74	Full-circle programming off
G75	Full-circle programming on

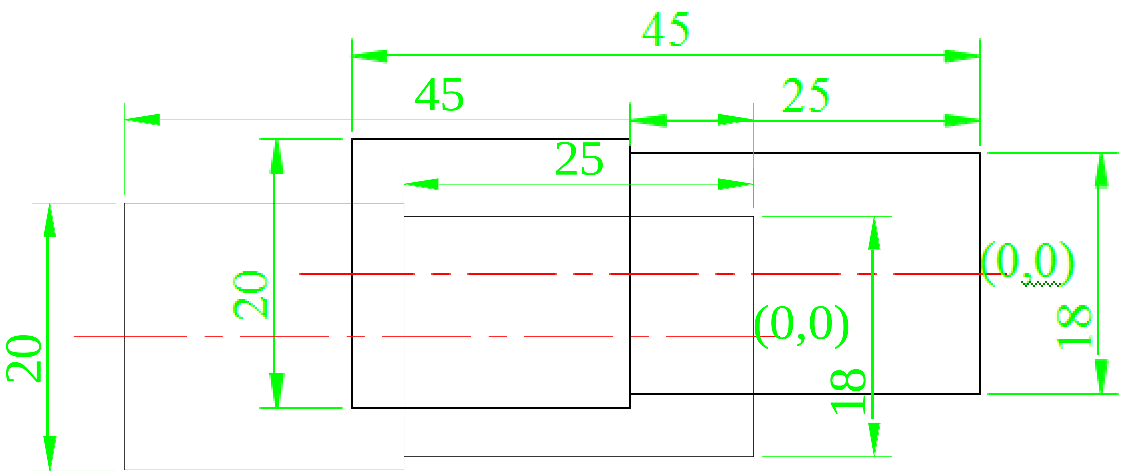
- G80 Fixed-cycle cancel
- G81-G89 Fixed cycles
- G90 Absolute dim
- G91 Incremental positioning
- G94 Feed rate in mm/min
- G95 Feed rate in mm/rev
- G96 speed in m/min
- G97 speed in rev/min

M-Codes

- M00 Program stop
- M01 Optional program stop
- M02 Program end
- M03 Spindle on clockwise
- M04 Spindle on counterclockwise
- M05 Spindle stop
- M06 Tool change
- M08 Coolant on
- M09 Coolant off
- M10 Clamps on
- M11 Clamps off
- M30 Program stop, reset to start

Steps to write manual programming for the given Parts

1.



N010 G90G71G95G96

N020 M06 T01

NO30 M03 S500

NO40 GOOX10 Z1

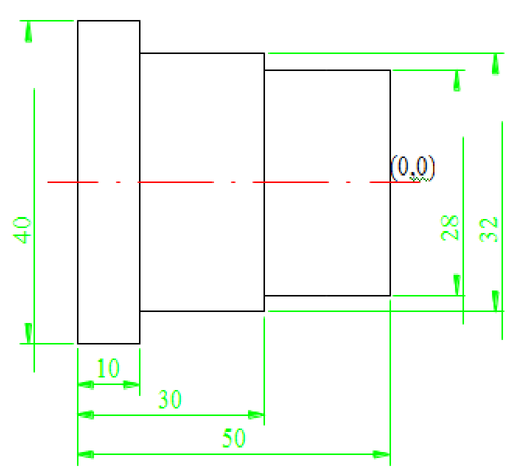
NO50 G01 Z-25F

NO60 GOOX30Z-23

NO70 MO5

NO80 MO2

2.



NO1 G90G71G95G96

NO2 M06TO1

NO3 MO3S700

N04GOOX20 Z2

NO5 GO1Z-50F10

NO6 GO1 X23

NO7 GOO Z1

NO8 X18

NO9 GO1 Z-40 F10

NO10 X20

NO11 GOO Z2

N012 X16

NO13GO1 Z-40 F10

NO14 X18

NO15 GOOZ2

NO16 X14

NO17 GO1 Z-20 F10

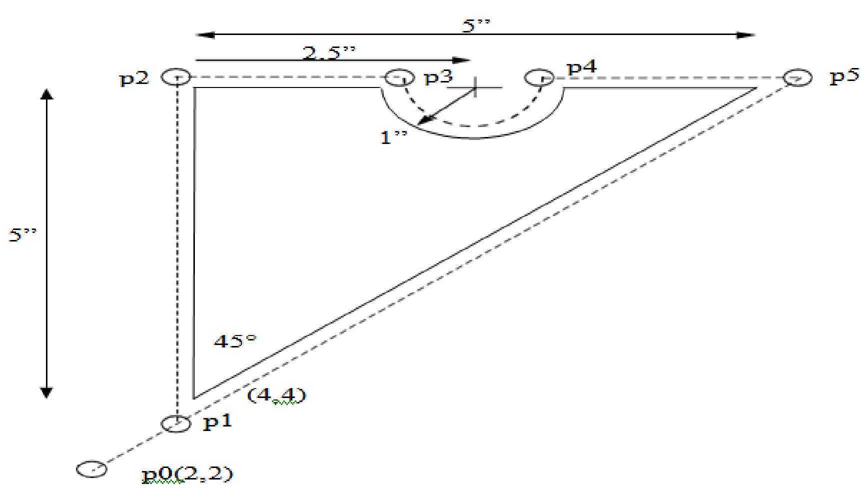
NO18 X16

NO19 GOO X50 Z40

NO20 MO5

NO21 M02

3. ManualPartProgrammingassumesthatwehaveToolsize=0.25inch,Feedrate=6 inch per minute, Cutting speed = 300 rpm, Tool start position: 2.0, 2.0.



N010G70 G90G94 G97M04

N020G17G75F6.0S300T1001M08 N030

G01 X3.875 Y3.698

N040G01X3.875Y9.125

N050G01 X5.634 Y9.125

N060G03X7.366Y9.125I0.866J-0.125

N070 G01 X9.302

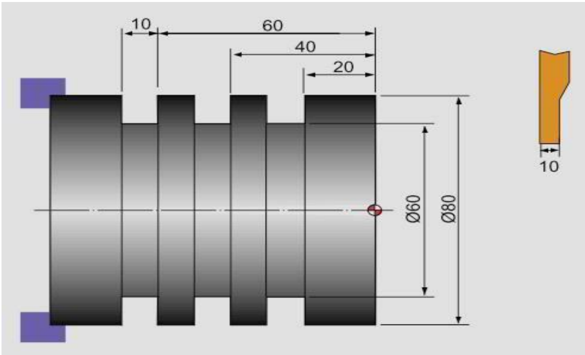
N080G01X3.875Y3.698

N090G01 X2.0Y2.0 M30

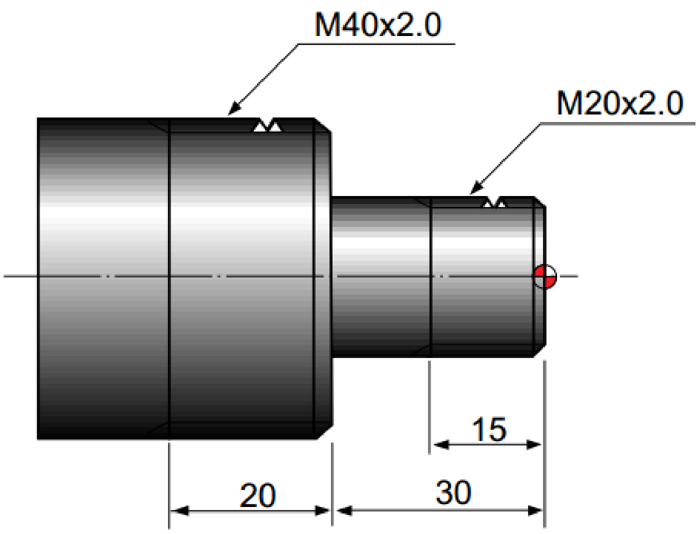
LAP Test

Instruction: Write manual programming for the given parts.

Tasks 1: Write programming Canned Cycle Grooving.



Tasks 2: Write the programming of thread cycle.



Reference

1. "Mechanical Engineering Design" by Joseph Shigley and Charles Mischke "
2. Machine Design: An Integrated Approach" by Robert L. Norton
3. Engineering Mechanics: Dynamics" by J.L. Meriam and L.G. Kraige
4. "Fundamentals of Fluid Mechanics" by Bruce R. Munson, AlricPelcowitzRothmayer, and Theodore H. Okiishi
5. "Engineering Drawing and Design" by David A. Madsen and David P. Madsen
6. "Mastering AutoCAD 2023 and AutoCAD LT 2023" by Brian C. Benton and George Omura
7. "The Project Manual: Writing Specifications for Construction" by William B. Moyer
8. "Mechanical Systems: Analysis and Design" by R. C. Hibbeler
9. "Product Design and Development" by Karl T. Ulrich and Steven D. Eppinger
10. "Drawing and Designing with Confidence: A Step-by-Step Guide" by David L. Fagerstrom

The Trainers Who Developed the TM

No	Name	Qualification	Educational background	Region	College	Mobile number	E-mail
1	KebedeTadesse	A	Mechanical Engineering	Oromiya	MGMBPTC	0911355094	kebedetad2016@gmail.com
2	FirewBekele	A	Manufacturing Technology	Amhara	D//Berahan PTC	0910826193	Firewbekele652@gmail.com
3	WelelaSeid	A	Manufacturing Engineering	Sidama	Hawasa PTC	0912134346	wolelaseid11@gmail.com