UNIT – 1 **Design Philosophy**

Problem Identification- Problem Statement, Specifications, Constraints, Feasibility Study-Technical Feasibility, Economic & Financial Feasibility, Social & Environmental Feasibility, Generation of Solution Field (Solution Variants), Brain Storming, Preliminary Design, Selection of Best Possible Solution, Detailed Design, Selection of Fits and Tolerances and Analysis of Dimensional Chains.

## ➢ Introduction to Machine Design

Machine Design is the innovation of new and effective machines and improving the existing ones.

A new or effective machine is one which is more economical in the overall cost of production and operation.

The design is to formulate a plan for the satisfaction of a human need.

In designing a machine component, it is necessary to have a good knowledge of many subjects such as Mathematics, Engineering Mechanics, Strength of Materials, Theory of Machines, Workshop Processes and Engineering Drawing.

## ➢ Classifications of Machine Design

The machine design may be classified as follows:

1. **Adaptive design:** In this the designer's work is concerned with adaptation of existing designs. The designer only makes minor alternation or modification in the existing designs of the product.

2. **Development design:** This type of design needs scientific training and design ability in order to modify the existing designs into a new idea by adopting a new material or different method of manufacture.

3. **New design:** This type of design needs lot of research, technical ability and creative thinking. Only those designers who have personal qualities of a sufficiently high order can take up the work of a new design.

4. **Rational design:** This type of design depends upon mathematical formulae of principle of mechanics.

5. **Empirical design:** This type of design depends upon empirical formulae based on the practice and past experience.

6. **Industrial design:** This type of design depends upon the production aspects to manufacture any machine component in the industry.

7. **Optimum design:** It is the best design for the given objective function under the specified constraints. It may be achieved by minimizing the undesirable effects.

8. **System design:** It is the design of any complex mechanical system like a motor car.

9. **Element design:** It is the design of any element of the mechanical system like piston, crankshaft, connecting rod, etc.

10. **Computer aided design:** This type of design depends upon the use of computer systems to assist in the creation, modification, analysis and optimization of a design.

## ➢ General Procedure in Machine Design

In designing a machine component, there is no rigid rule. The problem may be attempted in several ways. However, the general procedure to solve a design problem is as follows:

1. **Need or Aim**: First of all, make a complete statement of the problem, indicating the need, aim or purpose for which the machine is to be designed.

2. **Synthesis (Mechanisms)**: Select the possible mechanism or group of mechanisms which will give the desired motion.

3. **Analysis of forces**: Find the forces acting on each member of the machine and the energy transmitted by each member.

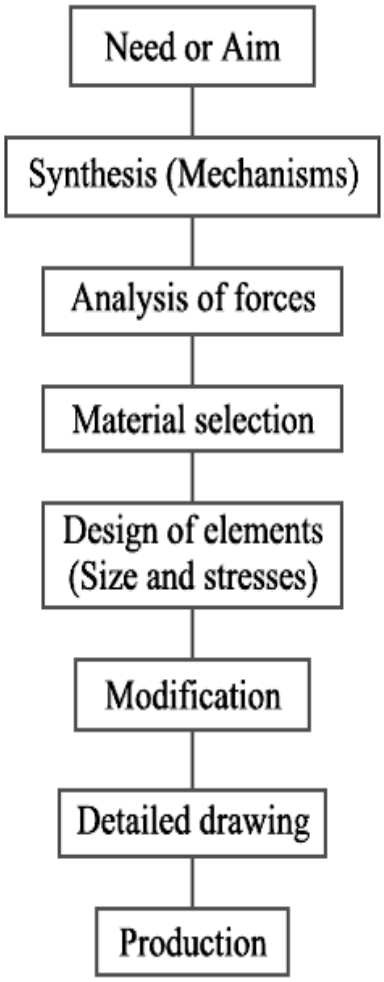
4. **Material selection**: Select the material best suited for each member of the machine.

5. **Design of elements (Size and Stresses)**: Find the size of each member of the machine by considering the force acting on the member and the permissible stresses for the material used. It should be kept in mind that each member should not deflect or deform than the permissible limit.

6. **Modification**: Modify the size of the member to agree with the past experience and judgment to facilitate manufacture. The modification may also be necessary by consideration of manufacturing to reduce overall cost.

7. **Detailed drawing**: Draw the detailed drawing of each component and the assembly of the machine with complete specification for the manufacturing processes suggested.

8. **Production**: The component, as per the drawing, is manufactured in the workshop.



## ➢ Feasibility Study:

Feasibility studies address things like where and how the business will operate. They provide in-depth details about the business to determine if and how it can succeed, and serve as a valuable tool for developing a winning business plan.

Feasibility studies contain comprehensive, detailed information about your business structure, your products and services, the market, logistics of how you will actually deliver a product or service, the resources you need to make the business run efficiently, as well as other information about the business.

A feasibility study is an evaluation of a proposal designed to determine the difficulty in carrying out a designated task. Generally, a feasibility study precedes technical development and project implementation. In other words, a feasibility study is an evaluation or analysis of the potential impact of a proposed project.

### ❖ The Components of a Feasibility Study

Description of the Business: The product or services to be offered and how they will be delivered.

1. **Technical Feasibility (Technology and system feasibility)**: The assessment is based on an outline design of system requirements in terms of Input, Processes, Output, Fields, Programs, and Procedures. This can be quantified in terms of volumes of data, trends, frequency of updating, etc. in order to estimate whether the new system will perform adequately or not. Technological feasibility is carried out to determine whether the company has the capability, in terms of software, hardware, personnel and expertise, to handle the completion of the project. Details how you will deliver a product or service (i.e., materials, labor, transportation, where your business will be located, technology needed, etc.).

2. **Economic feasibility**: Economic analysis is the most frequently used method for evaluating the effectiveness of a new system. More commonly known as cost/benefit analysis, the procedure is to determine the benefits and savings that are expected from a candidate system and compare them with costs. If benefits outweigh costs, then the decision is made to design and implement the system. An entrepreneur must accurately weigh the cost versus benefits before taking an action. Cost-based study: It is important to identify cost and benefit factors, which can be categorized as follows:

   - ✓ Development costs
   - ✓ Operating costs

   This is an analysis of the costs to be incurred in the system and the benefits derivable out of the system. Time-based study: This is an analysis of the time required to achieve a return on investments. The benefits derived from the system. The future value of a project is also a factor. Includes a description of the industry, current market, anticipated future market potential, competition, sales projections, potential buyers, etc.

3. **Financial Feasibility**: Projects how much start-up capital is needed, sources of capital, returns on investment, etc.

4. **Social and Environmental Feasibility:** Social and Environmental Feasibility are as following types:

   a. **Legal feasibility**: Determines whether the proposed system conflicts with legal requirements, e.g. a data processing system must comply with the local Data Protection Acts.

   b. **Operational feasibility**: Operational feasibility is a measure of how well a proposed system solves the problems, and takes advantage of the opportunities identified during scope definition and how it satisfies the requirements identified in the requirements analysis phase of system development.

   c. **Schedule feasibility**: A project will fail if it takes too long to be completed before it is useful. Typically this means estimating how long the system will take to develop, and if it can be completed in a given time period using some methods like payback period. Schedule feasibility is a measure of how reasonable the project timetable is. Given our technical expertise, are the project deadlines reasonable? Some projects are initiated with specific deadlines. You need to determine whether the deadlines are mandatory or desirable.

## ➢ Brainstorming

Brain storming is a technique used to gather a large quantity of ideas. The ideas generated are geared towards solving a specific problem. There are different brainstorming techniques which have been used. They are however, often group creativity techniques, whereby a group of individuals join together so as to find a solution to a specific problem.

Brainstorming has grown religiously beneficial to various purposes since its mainly known introduction in the end of 1930s. The book entitled Applied Imagination by Alex Faickney Osborn, emphasized on the effectiveness of creativity which is derived from group work.

Brainstorming is a commonly used tool amidst academic, researchers and business teams. Nevertheless, the effectiveness has hardly been proven through results. There are clear evidences derived from in-depth scrutinized research proving the contrary; group working has its negative aspects such as social loafing, distraction, anxiety, coordination problems. It has even been assumed that people working in groups tend to be less productive than those who work independently.

The impact of brainstorming on the productivity in generating ideas is not certified as being certitude. There are, however, some direct psychological benefits derived from brainstorming such as motivation derived from work enjoyment, job satisfaction, boost of moral and improved team working environment.

The traditional brainstorming technique is constantly being innovated and evolves to remove inefficiencies present in brainstorming techniques.

The use of brainstorming is becoming an exceedingly common technique to gather ideas for both academic and business purposes. The group approach used in brainstorming has several

varied benefits such as improving relationship amidst colleagues and participants. Advanced models of brainstorming that have and are being developed are geared towards bring even further benefits in the productiveness in the process of gathering ideas.

- **There are four basic rules in brainstorming**: These are intended to reduce social inhibitions among group members, stimulate idea generation, and increase overall creativity of the group.

  Focus on quantity: This rule is a means of enhancing divergent production, aiming to facilitate problem solving through the maxim quantity breeds quality. The assumption is that the greater the number of ideas generated, the greater the chance of producing a radical and effective solution.

  Withhold criticism: In brainstorming, criticism of ideas generated should be put 'on hold'. Instead, participants should focus on extending or adding to ideas, reserving criticism for a later 'critical stage' of the process. By suspending judgment, participants will feel free to generate unusual ideas.

  Welcome unusual ideas: To get a good and long list of ideas, unusual ideas are welcomed. They can be generated by looking from new perspectives and suspending assumptions. These new ways of thinking may provide better solutions.

  Combine and improve ideas: Good ideas may be combined to form a single better good idea, as suggested by the slogan "1+1=3". It is believed to stimulate the building of ideas by a process of association.

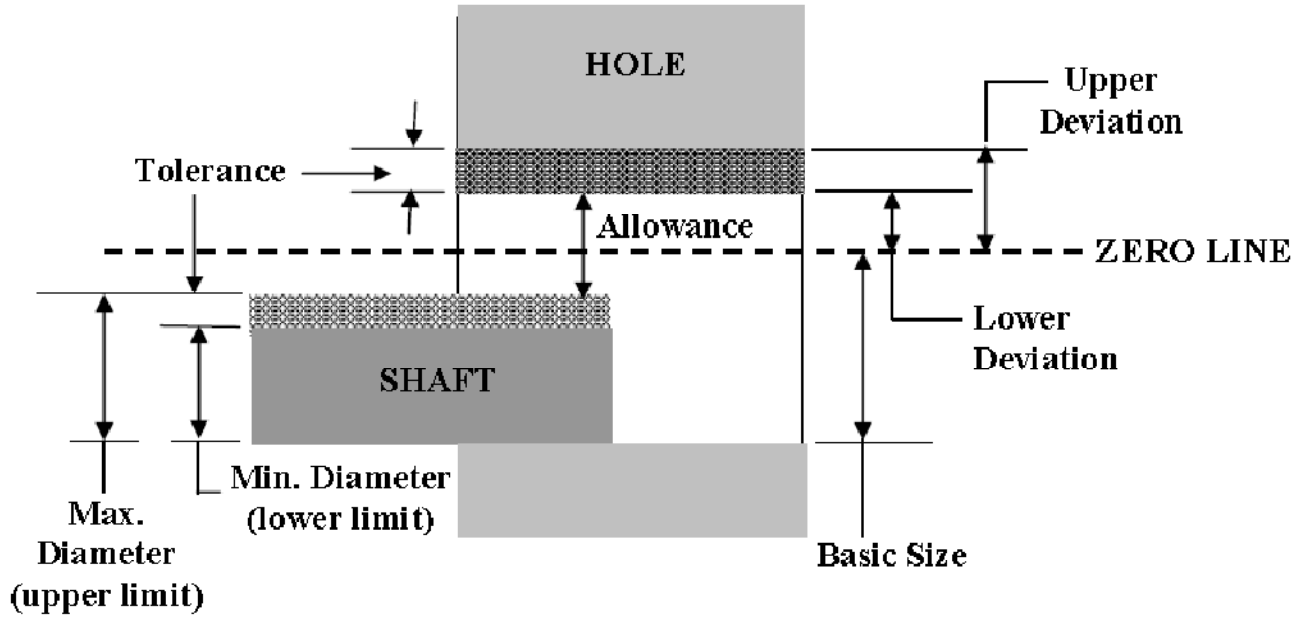
## Design and Manufacturing

A machine element, after design, requires to be manufactured to give it a shape of a product. Therefore, in addition to standard design practices like, selection of proper material, ensuring proper strength and dimension to guard against failure, a designer should have knowledge of basic manufacturing aspects.

First and foremost is assigning proper size to a machine element from manufacturing view point. As for example, a shaft may be designed to diameter of, say, 40 mm. This means, the nominal diameter of the shaft is 40 mm, but the actual size will be slightly different, because it is impossible to manufacture a shaft of exactly 40 mm diameter, no matter what machine is used. In case the machine element is a mating part with another one, then dimensions of both the parts become important, because they dictate the nature of assembly. The allowable variation in size for the mating parts is called limits and the nature of assembly due to such variation in size is known as fits.

## Limits

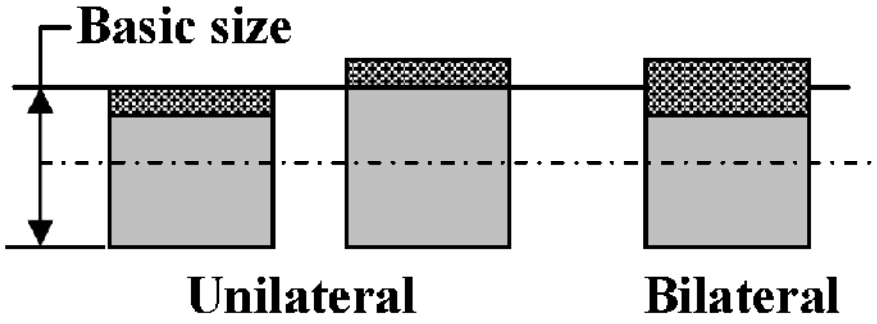
Below Fig. explains the terminologies used in defining tolerance and limit. The zero line, shown in the figure, is the basic size or the nominal size. The definition of the terminologies is given below. For the convenience, shaft and hole are chosen to be two mating components.




## ➢ Tolerance

Tolerance is the difference between maximum and minimum dimensions of a component, i.e. between upper limit and lower limit. Depending on the type of application, the permissible variation of dimension is set as per available standard grades.

Tolerance is of two types, bilateral and unilateral. When tolerance is present on both sides of nominal size, it is termed as bilateral; unilateral has tolerance only on one side.




This Fig. shows the types of tolerance

$50^{0}_{-y}$ , $50^{+x}_{0}$ and $50^{+x}_{-y}$

It is a typical example of specifying tolerance for a shaft of nominal diameter of 50mm.

First two values denote unilateral tolerance and the third value denotes bilateral tolerance. Values of the tolerance are given as x and y respectively.

**Allowance**: It is the difference of dimension between two mating parts.

**Upper deviation**: It is the difference of dimension between the maximum possible size of the component and its nominal size.

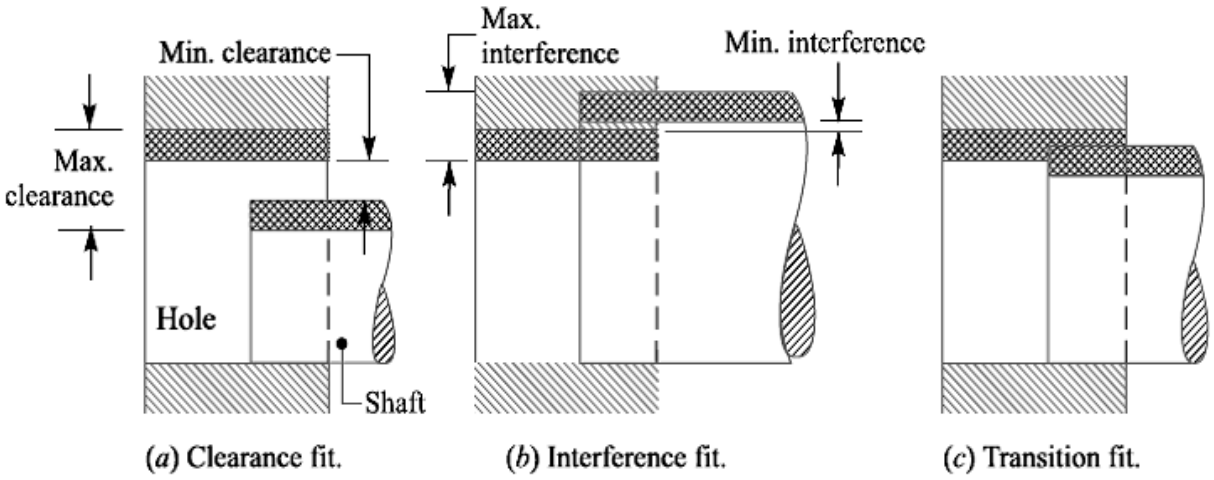
**Lower deviation**: Similarly, it is the difference of dimension between the minimum possible size of the component and its nominal size.

**Fundamental deviation**: It defines the location of the tolerance zone with respect to the nominal size. For that matter, either of the deviations may be considered.

## ➢ Fits

The degree of tightness or looseness between the two coupling parts is known as a fit of the parts.

The nature of fit is characterized by the presence and size of clearance and interference. The clearance is the amount by which the actual size of the shaft is less than the actual size of the mating hole in an assembly as shown in Fig. In other words, the clearance is the difference between the sizes of the hole and the shaft before assembly. The difference must be positive. The interference is the amount by which the actual size of a shaft is larger than the actual finished size of the mating hole in an assembly as shown in Fig. In other words, the interference is the arithmetical difference between the sizes of the hole and the shaft, before assembly. The difference must be negative.




(*a*) Clearance fit. (*b*) Interference fit. (*c*) Transition fit.

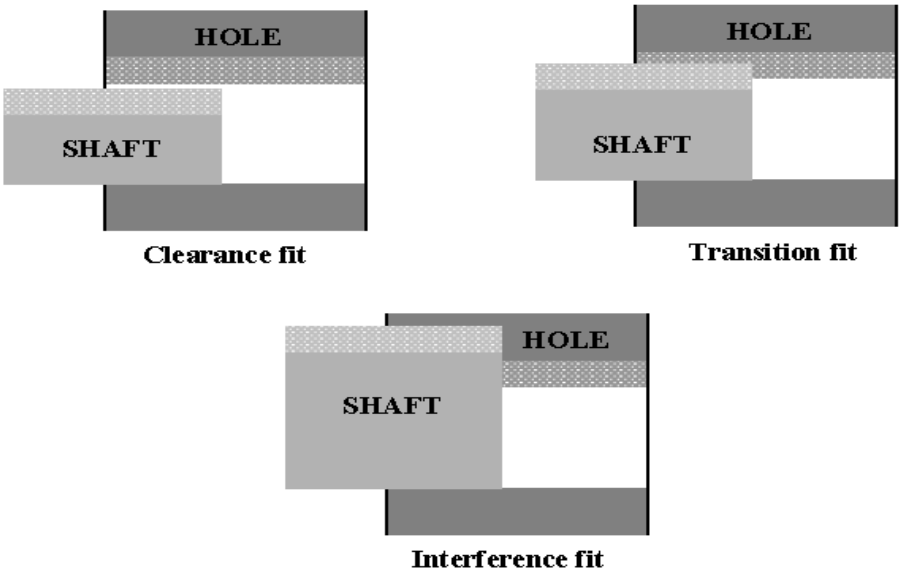
### ➢ Types/Selection of Fits

According to Indian standards, the fits are classified into the following three groups:

a) **Clearance Fit:** In this type of fit, the shaft of largest possible diameter can also be fitted easily even in the hole of smallest possible diameter.

b) **Transition Fit:** In this case, there will be a clearance between the minimum dimension of the shaft and the minimum dimension of the hole. If we look at the figure carefully, then it is observed that if the shaft dimension is maximum and the hole dimension is minimum then an overlap will result and this creates a certain amount of tightness in the fitting of the shaft inside the hole. Hence, transition fit may have either clearance or overlap in the fit.

c) **Interference Fit:** In this case, no matter whatever may be the tolerance level in shaft and the hole, there is always a overlapping of the matting parts. This is known as interference fit. Interference fit is a form of a tight fit.




## ➢ Detailed Design

After doing the preliminary design and development of the machine the next important step is making the detailed design of the machine or product (see the fig below). This stage of the machine design cycle should not be confused or mixed with the previous stage of making the preliminary design. Many designers think that all the designing that has been done in the preliminary stage is quite sufficient, but this is a wrong notion. At the preliminary design stage certain changes can be made in the design, but once it has been finalized no further changes can be made. The details of the finalized design are worked out in the detailed design stage of the machine design cycle.

During the detailed design stage all the parts of the machine are defined clearly and also how they will work in tandem with each other to make a fully functional machine. The details are found out for all the parts right from the biggest parts of the machine to the nuts and bolts for the machine. There are no doubts left regarding the elements to be used in the machine, their size, strength, materials etc and how they will work. The working mechanism of the whole machine is defined in all the minute details.

During the detailed design stage the complete drawing of the assembly of the machine and all the individual machine elements of the machine is made. The drawings include all the dimensions of all the components, the permissible tolerance for manufacturing them, the

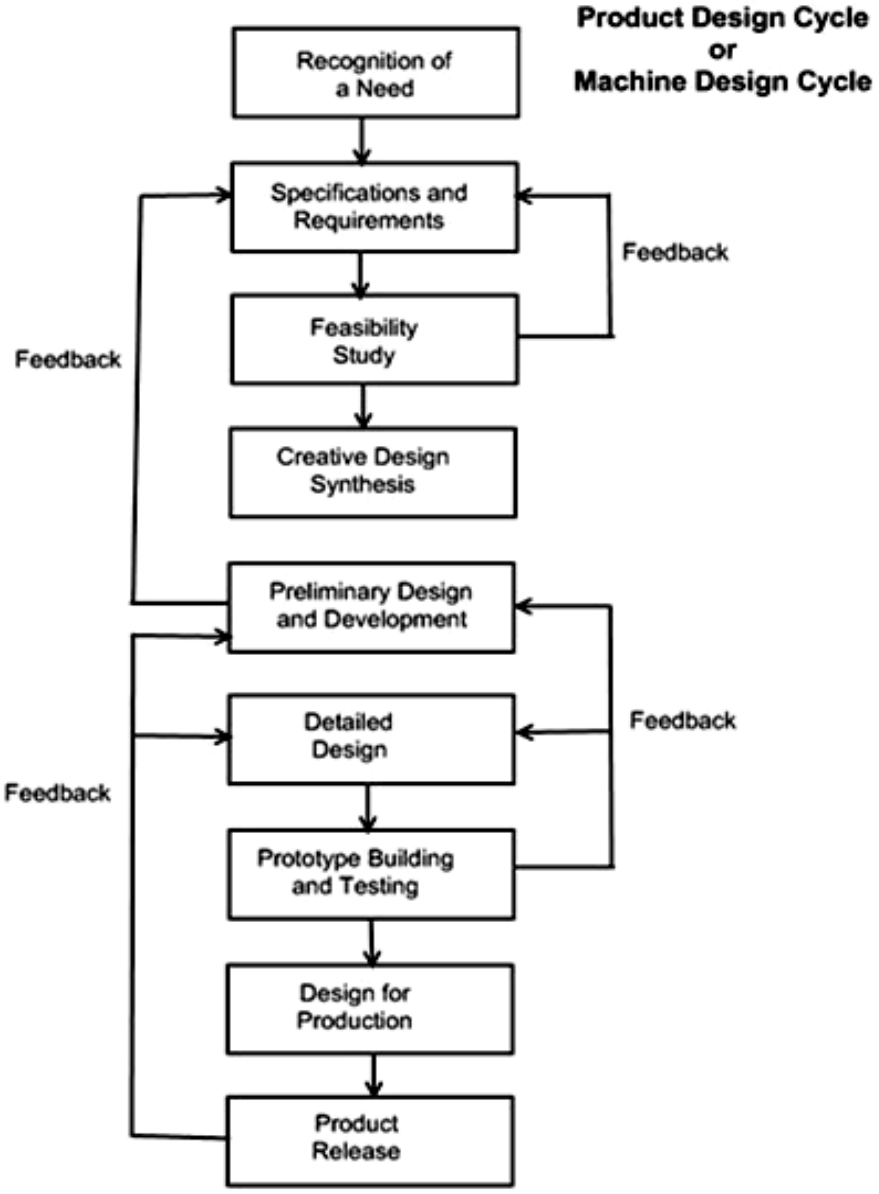
materials for manufacturing and the method of manufacturing the components. Thus the detailed design comprises of all the detailed specifications of the whole machine as well as all the components or elements of the machine.

There are two **important activities** carried out during detailed design stage of machine design cycle, these are:

a) Detailing the parts, components, and their assembly.
b) Finalizing the details of methods of fabrication or manufacturing the machine and its components.

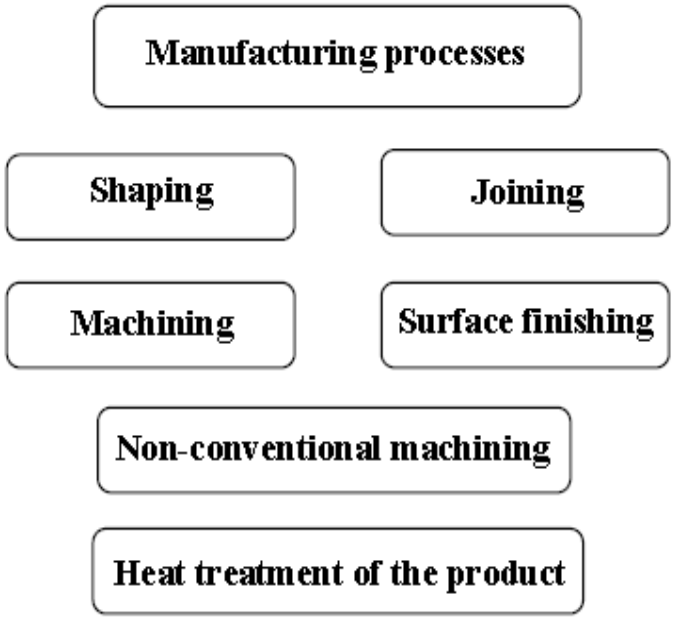
To complete the detailed design stage successfully the designer should have sound technical knowledge about the machine, its components, the materials to be used, the available manufacturing processes, the limitations and capacities of the machines etc. If the designer lacks in this knowledge, they should consult the competent authorities to get full information before carrying the process of detailed design. To successfully carry out the detailed design procedure it is desired that the designer has good knowledge of strength of materials, theory of machines, thermodynamics, fluid mechanics, electromagnetics, etc.

During the detailed design other factors to be considered are efficiency of the machine, safety margins, quality standards, appearance of the machines etc. Many times a good design has to be abandoned due to reasons like tooling, machining, and manufacturing processes. Hence considering all the relevant factors at this stage is crucial, because once the detailed design is done, the prototype of the actual machine will be made to see of it can work properly.

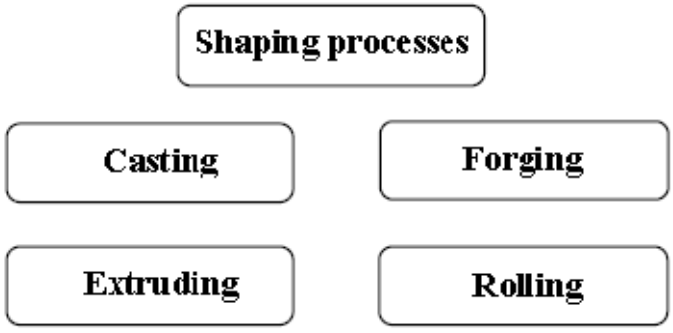


## ➢ Common manufacturing processes

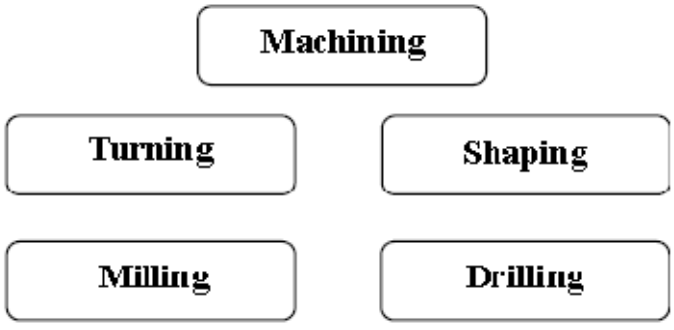
1. The types of common manufacturing processes are given below:



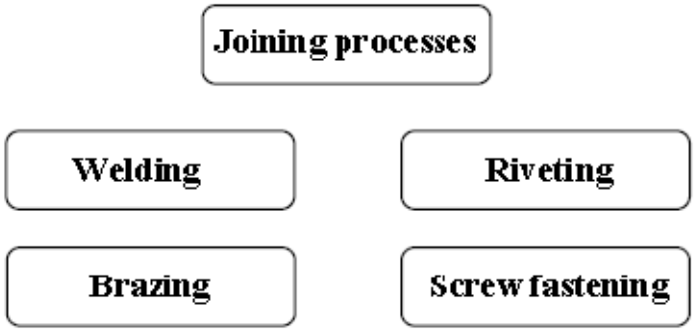

2. The types of shaping processes are given below:



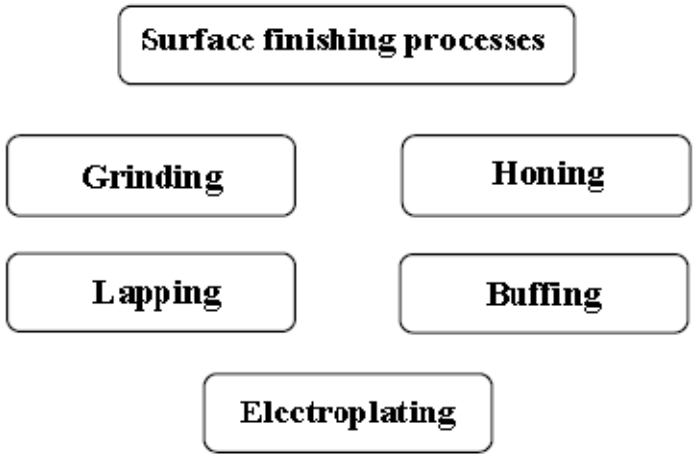

3. Following are the type of machining processes, shown:



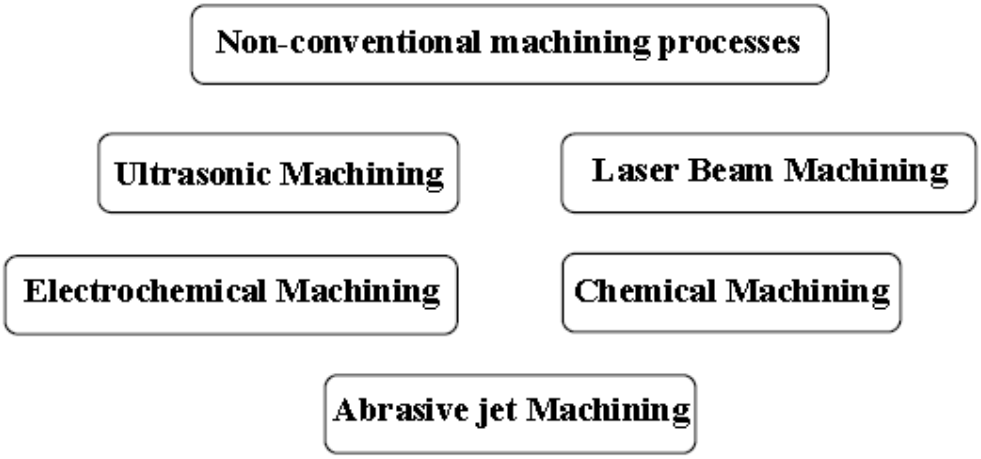
4. Various joining processes are shown:




5. The surface finishing processes are given below:




6. The non-conventional machining processes are as follows:



# Assignment No:-1

Q1. What is meant by tolerance? How many types of tolerance are there?

Q2. What are the types fit? Describe the different types?

Q3. Describe Brain storming as an operational technique of idea generation?

Q4. Define Feasibility Study? And classify its type's briefly?

Q5. Explain manufacturing process consideration?

Q6. Discuss the Detailed Design In brief?

Q7. What is Design Philosophy? And Classification of machine design?

(Note: Design philosophy includes; Definition of machine design, Classification of machine design and general producer in machine design)