1. REPORT WRITING ON GENERAL DESIGN PROCEDURE.

1.1 General Considerations in Machine Design:-

Following are the general considerations in designing a machine component:

1. **Type of load and stresses caused by the load.**

The load, on a machine component, may act in several ways due to which the internal stresses are set up.

2. **Motion of the parts or kinematics of the machine.**

The successful operation of any machine depends largely upon the simplest arrangement of the parts which will give the motion required. The motion of the parts may be:

(a) Rectilinear motion which includes unidirectional and reciprocating motions.

(b) Curvilinear motion which includes rotary, oscillatory and simple harmonic.

(c) Constant velocity.

(d) Constant or variable acceleration.

3. **Selection of materials.**

It is essential that a designer should have a thorough knowledge of the properties of the materials and their behavior under working conditions. Some of the important characteristics of materials are: strength, durability, flexibility, weight, resistance to heat and corrosion, ability to cast, welded or hardened, machinability, electrical conductivity, etc.

4. **Form and size of the parts.**

The form and size are based on judgment. The smallest practicable cross-section may be used, but it may be checked that the stresses induced in the designed cross-section are reasonably safe. In order to design any machine part for form and size, it is necessary to know the forces which the part must sustain. It is also important to anticipate any suddenly applied or impact load which may cause failure.

5. **Frictional resistance and lubrication.**

There is always a loss of power due to frictional resistance and it should be noted that the friction of starting is higher than that of running friction. It is, therefore, essential that a careful attention must be given to the matter of lubrication of all surfaces which move in contact with others, whether in rotating sliding or rolling bearings.

6. **Convenient and economical features.**

In designing, the operating features of the machine should be carefully studied. The starting, controlling and stopping levers should be located on the basis of convenient handling. The adjustment for wear must be provided employing the various take-up devices and arranging them so that the alignment of parts is preserved. If parts are to be changed for different products or replaced on account of wear or breakage, easy access should be provided and the necessity of removing other parts to accomplish this should be avoided if possible.

The economical operation of a machine which is to be used for production or for the processing of material should be studied, in order to learn whether it has the maximum capacity consistent with the production of good work.

7. Use of standard parts.

The use of standard parts is closely related to cost, because the cost of standard or stock parts is only a fraction of the cost of similar parts made to order.

The standard or stock parts should be used whenever possible; parts for which patterns are already in existence such as gears, pulleys and bearings and parts which may be selected from regular shop stock such as screws, nuts and pins. Bolts and studs should be as few as possible to avoid the delay caused by changing drills, reamers and taps and also to decrease the number of wrenches required.

8. Safety of operation.

Some machines are dangerous to operate, especially those which are speeded up to insure production at a maximum rate. Therefore, any moving part of a machine which is within the zone of a worker is considered an accident hazard and may be the cause of an injury. It is, therefore, necessary that a designer should always provide safety devices for the safety of the operator. The safety appliances should in no way interfere with operation of the machine.

9. Workshop facilities.

A design engineer should be familiar with the limitations of his employer's workshop, in order to avoid the necessity of having work done in some other workshop. It is sometimes necessary to plan and supervise the workshop operations and to draft methods for casting, handling and machining special parts.

10. Number of machines to be manufactured.

The number of articles or machines to be manufactured affects the design in a number of ways. The engineering and shop costs which are called fixed charges or overhead expenses are distributed over the number of articles to be manufactured.

If only a few articles are to be made, extra expenses are not justified unless the machine is large or of some special design. An order calling for small number of the product will not permit any undue expense in the workshop processes, so that the designer should restrict his specification to standard parts as much as possible.

11. Cost of construction.

The cost of construction of an article is the most important consideration involved in design. In some cases, it is quite possible that the high cost of an article may immediately bar it from further considerations.

If an article has been invented and tests of hand made samples have shown that it has commercial value, it is then possible to justify the expenditure of a considerable sum of money in the design and development of automatic machines to produce the article, especially if it can be sold in large numbers. The aim of design engineer under all conditions should be to reduce the manufacturing cost to the minimum.

12. Assembling.

Every machine or structure must be assembled as a unit before it can function. Large units must often be assembled in the shop, tested and then taken to be transported to their place of service. The final location of any machine is important and the design engineer must anticipate the exact location and the local facilities for erection.

1.2 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. **Recognition of need.**

   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.

1.3 S.I. Units:-

1. **Fundamental Units**

The measurement of physical quantities is one of the most important operations in engineering. Every quantity is measured in terms of some arbitrary, but internationally accepted units, called **Fundamental units.**

2. Derived Units

Some units are expressed in terms of other units, which are derived from fundamental units, are known as **Derived units** e.g. the unit of area, velocity, acceleration, pressure, etc.

Table: Fundamental Units

Sr. No.	Physical Quantities	SI Units
1.	Length	Metre(m)
2.	Mass	Kilogram(kg)
3.	Time	Second(s)
4.	Temperature	Kelvin(K)
5.	Electric Current	Ampere(A)

Table: Derived Units

Sr. No.	Physical Quantities	SI Units
1.	Velocity	m/s
2.	Acceleration	m/s^2
3.	Mass-Density	kg/m^3
4.	Force	$kg \cdot m/s^2$ or N
5.	Couple	$N \cdot m$
6.	Momentum	$kg \cdot m/s$
7.	Torque	$N \cdot m$
8.	Power	J/s or W
9.	Work	J
10.	Energy	J

1.4 Definitions:-

1. Mass

It is the amount of matter contained in a given body and does not vary with the change in its position on the earth's surface.

2. Weight

It is the amount of pull, which the earth exerts upon a given body.

3. Inertia

It is that property of a matter, by virtue of which a body cannot move of itself nor change the motion imparted to it.

4. Force

It is an important factor in the field of engineering science, which may be defined as an agent, which produces or tends to produce, destroy or tends to destroy motion.

5. Couple

The two equal and opposite parallel forces, whose lines of action are different form a couple.

6. Momentum

It is the total motion possessed by a body.

Momentum = Mass × Velocity

7. Torque

It may be defined as the product of force and the perpendicular distance of its line of action from the given point or axis.

8. Power

It may be defined as the rate of doing work or work done per unit time.

9. Work

Whenever a force acts on a body and the body undergoes a displacement in the direction of the force, then work is said to be done.

10. Energy

It may be defined as the capacity to do work. The energy exists in many forms e.g. mechanical, electrical, chemical, heat, light, etc.

1.5 Stress & Stress:-

1. Stress

When some external system of forces or loads act on a body, the internal forces (equal and opposite) are set up at various sections of the body, which resist the external forces. This internal force per unit area at any section of the body is known as unit stress or simply a stress.

2. Strain

When a system of forces or loads act on a body, it undergoes some deformation. This deformation per unit length is known as unit strain or simply a strain.

1.5.1 Tensile Stress and Strain:

When a body is subjected to two equal and opposite axial pulls P (also called tensile load), then the stress induced at any section of the body is known as **tensile stress.**

A little consideration will show that due to the tensile load, there will be a decrease in cross-sectional area and an increase in length of the body. The ratio of the increase in length to the original length is known as **tensile strain.**

1.5.2 Compressive Stress and Strain:

When a body is subjected to two equal and opposite axial pushes P (also called compressive load), then the stress induced at any section of the body is known as **compressive stress.**

A little consideration will show that due to the compressive load, there will be an increase in cross-sectional area and a decrease in length of the body. The ratio of the decrease in length to the original length is known as **compressive strain.**

1.5.3 Shere Stress and Strain:

When a body is subjected to two equal and opposite forces acting tangentially across the resisting section, as a result of which the body tends to shear off the section, then the stress induced is called **shear stress** and the corresponding strain is known as **shear strain.**

1.6 Shere Modulus or Modulus of Rigidity:-

It has been found experimentally that within the elastic limit, the shear stress is directly proportional to shear strain.

Mathematically,

$$\tau = C \cdot \phi$$

τ = Shear stress,

ø = Shear strain, and

C = Constant of proportionality, known as shear modulus or modulus of rigidity. It is also denoted by N or G.

Hook's Law

" When a material is loaded, witihn its elastic limit, the stress is proportional to the strain."

Stress/Strain = E = constant

1.7 Stress & Strain Diagram:-

In designing various parts of a machine, it is necessary to know how the material will function in service. For this, certain characteristics or properties of the material should be known. The mechanical properties mostly used in mechanical engineering practice are commonly determined from a standard tensile test.

This test consists of gradually loading a standard specimen of a material and noting the corresponding values of load and elongation until the specimen fractures. The load is applied and measured by a testing machine.

The stress is determined by dividing the load values by the original cross-sectional area of the specimen. The elongation is measured by determining the amounts that two reference points on the specimen are moved apart by the action of the machine. The original distance between the two reference points is known **as gauge length.** The strain is determined by dividing the elongation values by the gauge length.

The values of the stress and corresponding strain are used to draw the stress-strain diagram of the material tested. A stress-strain diagram for a mild steel under tensile test is shown in Fig (a). The various properties of the material are discussed below:

1. **Proportional limit.**

We see from the diagram that from point O to A is a straight line, which represents that the stress is proportional to strain. Beyond point A, the curve slightly deviates from the straight line. It is thus obvious, that Hooke's law holds good up to point A and it is known as proportional limit. It is defined as that stress at which the stress-strain curve begins to deviate from the straight line.

2. **Elastic limit.**

It may be noted that even if the load is increased beyond point A upto the point B, the material will regain its shape and size when the load is removed. This means that the material has elastic properties up to the point B. This point is known as elastic limit. It is defined as the stress developed in the material without any permanent set.

3. **Yield point.**

If the material is stressed beyond point B, the plastic stage will-reach i.e. on the removal of the load, the material will not be able to recover its original size and shape. A little consideration will show that beyond point B, the strain increases at a faster rate with any increase in the stress until the point C is reached.

At this point, the material yields before the load and there is an appreciable strain without any increase in stress. In case of mild steel, it will be seen that a small load drops to D, immediately after yielding commences. Hence there are two yield points C and D. The points C and D are called the upper and lower yield points respectively. The stress corresponding to yield point is known as yield point stress.

4. **Ultimate stress.**

At D, the specimen regains some strength and higher values of stresses are required for higher strains, than those between A and D. The stress (or load) goes on increasing till the point E is reached. The gradual in uniform reduction of its cross-se transformed largely into heat and I specimen becomes hot. At E, t stress, which attains its maximi value is known as ultimate stress is defined as the largest stn obtained by dividing the largest va of the load reached in a test to i original cross-sectional area of i test piece.

5. Breaking stress.

After specimen has reached the ultim stress, a neck is formed, whi decreases the cross-sectional area the specimen. A little consideration will sh that the stress (or load) necessary break away the specimen, is less tl the maximum stress. The stress is stress corresponding to point F is known as Breaking Stress.

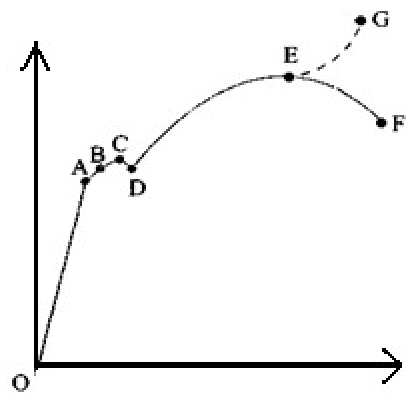

Figure (a) Stress and Strain Diagram

6. Percentage reduction in area.

It is the difference between the original cross-sectional area and cross-sectional area at the neck (i.e. where the fracture takes place). This difference is expressed as percentage of the original cross-sectional area.

Let A = Original cross-sectional area, and

a = Cross-sectional area at the neck.

Then reduction in area = A – a

And Percentage reduction in Area = [(A-a)/A] ×100

7. Percentage elongation.

It is the percentage increase in the standard gauge length (i.e. original length) obtained by measuring the fractured specimen after bringing the broken parts together.

Elongation = L – l

L = Length of specimen after fracture or final length

l = Gauge length or Original length

And Percentage elongation = [(L-l)/l] ×100

1.8 Bearing Stress:-

A localized compressive stress at the surface of contact between two members of a machine part, that are relatively at rest is known as bearing stress or crushing stress.

1.9 Factor of Safety:-

It is defined as the ratio of the maximum stress to the working stress.

Mathematically,

FACTOR OF SAFETY = Maximum Stress / Working or Design Stress

1.10 Torsional & Bending Stress:-

When a machine member is subjected to the action of two equal and opposite couples acting in parallel plans (or torque or twisting moment), then the machine member is said to be subjected to torsion. The stress set up by torsion is known as **torsional shear stress**.

The resistance, offered by the internal stresses, to the bending, is called **Bending Stress.**