[1]STRUCTURE

An a/c has mainly three structural component
i> Wing ii> Fuselage iii> Empennage group (Tail plane)

i> landing gear which helps in landing and take-off is also an important structure component.

Wing → An important structural member which produces enough lift to make flying possible (by pressure difference of upper and lower surfaces).

Construction →

i> Spar→ something like a girder with upper and lower flanges connected together with webs or struts . It transmits shear forces and takes up the bending moment which is trasmitted to its flanges.

Wings are either single, double, or multi spar.

Higher the load, more strong the construction should be, false spar which look like the spar but of lesser strength and of light weight are used in monospar to provide more strength to the wing. Strict monospar is not the common design used in a/c.

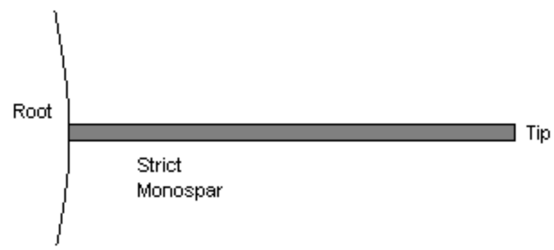
Double spar and multispar makes the wing very strong. Loads are now distributed evenly at these spars and wing can fly with additional load.

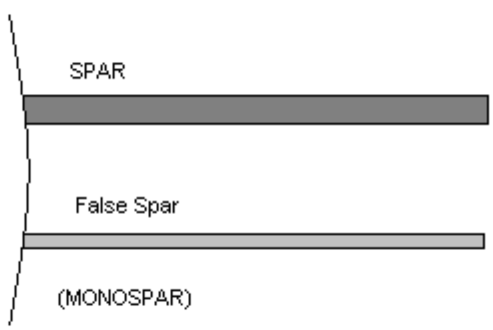
In case of monouvering and performance condition where many loads increase by significant amount use of multispar enables the wing to withstand all these increase loads.

1

Therefore in fighter aircraft and in other a/cs, operating under high load conditions multi-spars are generally used.

Since wing has to face(High incoming velocity of air flow increases shear force and torque etc.) greater load and resistance near its leading edge. The L.E. spar (in a double spar or multi spar wing) is located as near as possible to leading edge.

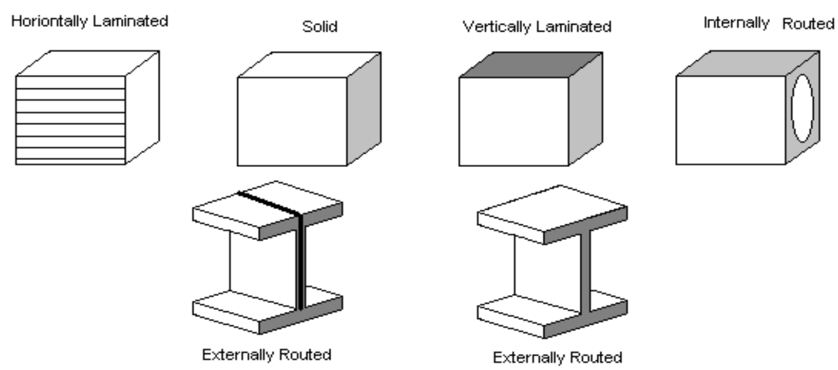




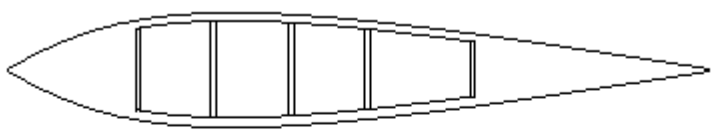
In case of double spar

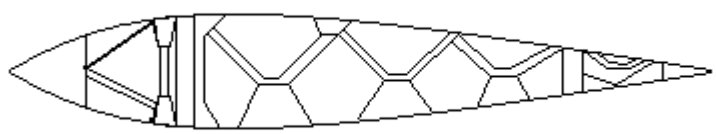
In case of multispar (example→ triple spar)

First spar is near to leading edge (to resist high load) Last spar is near to trailing edge (to resist forces caused by vortices, drag etc) middle spar in between. (to make the load uniform).



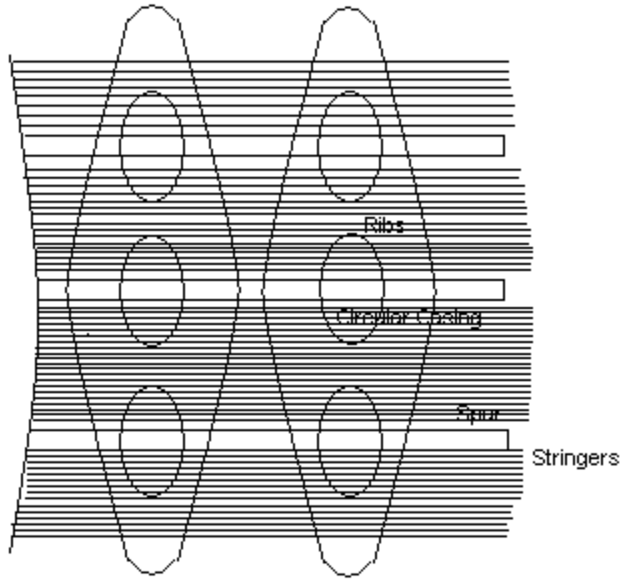
ii> Ribs → [Ribs are basic elements which forms the aerodynamic configuration of the wing. Wing covering is fixed to them them both directly and through stringers. They take up air load and transmit it to spars.] They have circular casing to make it light in weight and to provide more strength and toughness





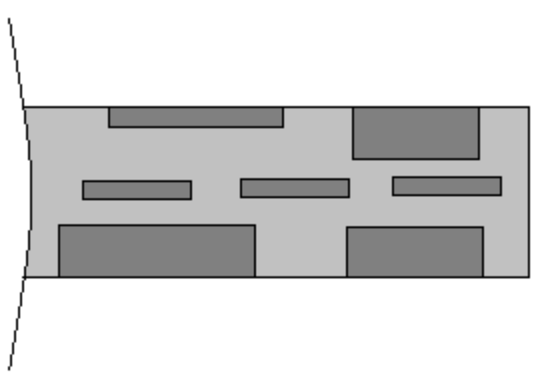
iii> Stringers → Longitudinal elements fixed to the upper and lower skin in order to give them stiffness and to take up together with the spar flanges the bending moment to vertical forces.

They are made of Al or Mg to make it light in weight they are riveted to ribs and give extra rigidity and strength to the structure.



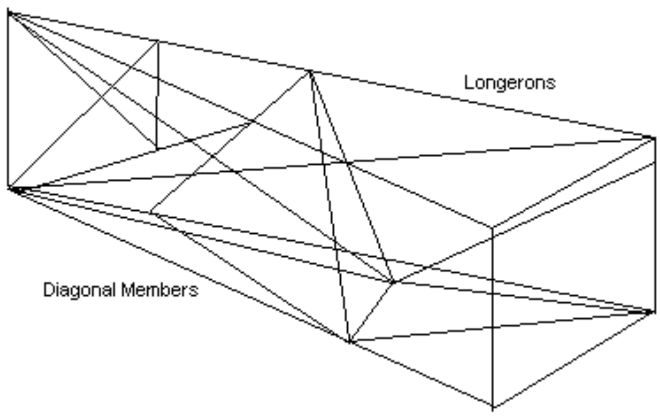
iv> Skin or covering → It covers the internal structure and hence gives the external view. It resists torque produced by the air load and also takes up considerable part of bending moment and transmits it to ribs and fuselage sheathing.

The higher the a/c flight velocity, the greater the velocity head and consiquently the load on the a/c elements. Therefore in order to provide the required strength and rigidity for fast a/c it becomes necessary to thicken the covering of the wing, tail plane and fuselage.[thick covering is used in fighter a/c or military aircraft].



Fuselage

Truss type → Generally used in some light, single engined a/c. It is constructed of steel (Al alloy) tubes welded (or, rivited or bolted) together in such a manner that all the members carry both tension and compression.



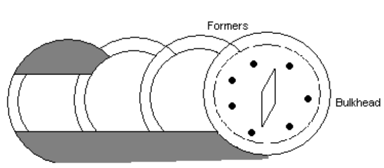
Monocoque type → Its construction largely depends on the strength of the skin. It is classified in two types.

1.> Monocoque type   2.> Semi-monocoque type

1. >Monocoque construction → This construction uses

→ **Formers, Frame Assemblers and Bulkheads to give shape to the fuselage.**

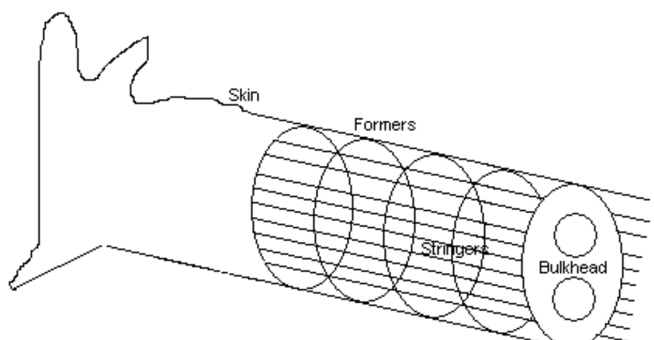
Here primary stresses are carried by the skin covering. The skin must be strong enough to keep the fuselage rigid. Thus the biggest probelem involved in monocoque construction is to maintain enough strength while keeping the weight within limit.



2. > Semi-Monocoque construction → Constructed of alloys of Al, Mg although steel and titanium are also used in area of high temparature. This construction uses

→ **Formers, Frame assemblers, Bulkhead, Stringers and Longerons.**

Stringers make it different than monocoque construction. They are light in weight, more in number and distribute the load more uniformly. Here primary bending loads are taken by longerons which extend across several points of supports. Stringers make the structure more rigid and stronger. The load is then transferred to heavy vertical members known as formers which are located at intervals and at the attatchment points to carry concentrated loads.



Semi-Monoqoue Construction

Advantages of Semi-Monocoque Over Monocoque Type

Semi-monocoque construction which uses stringers in addition to bulhead, frame-assemblies, formers and longeron to make the structure more strong while maintaining its light weight.

Uses of stringers which are densely fabricated distribute the load more uniformly. [This means it doesnt depend on a few members for strength and rigidity] and due to this stressed skin construction it may withstand considerable damage and still be strong enough to hold together.

Some Important Construction

Box-Beam → This type of construction uses two main longitudinal members. They are connected by ribs to increase the strength and to give required shape to the wing. A **corrugated shut** may be placed between the ribs and smooth outer skin so that the wing can carry tension and compression.

Fail Safe Spar

Structure may be designed so as to be considered fail-safe which means when one member of the complex structure fails, some other members takes the load of the failed member.

This type of spar is made in two sections. Upper top section consists of a cap riveted to the upper web plate. Lower section is a single extrsion (one piece) consisting of a lower cap and web plate.

These two sections are fixed together to form a spar. If either section of this type of spar breaks the other section will carry the load for a reasonable time period.

Some Important Defination and Short Notes

1. Creep and fatigue

   Fatigue → When materials are subjected to repeated loads it happens sometimes that materials fail at much smaller load then its designed value. This undesirable phenomenon is known asa fatigue and investigations disclosed that each materials has a fatigue stress beyond which it is not safe to load it repeatidly.

The fatigue limit of a material is ½ of its fatigue range.

For steel → fatigue limit is about 0.5 of ultimate tensile strength (UTS)

For Non-Ferrous metals → It is about 0.3 to 0.4 of the ultimate tensile strength (UTS)

Heat treatment increases the fatigue limit and tensile strength.

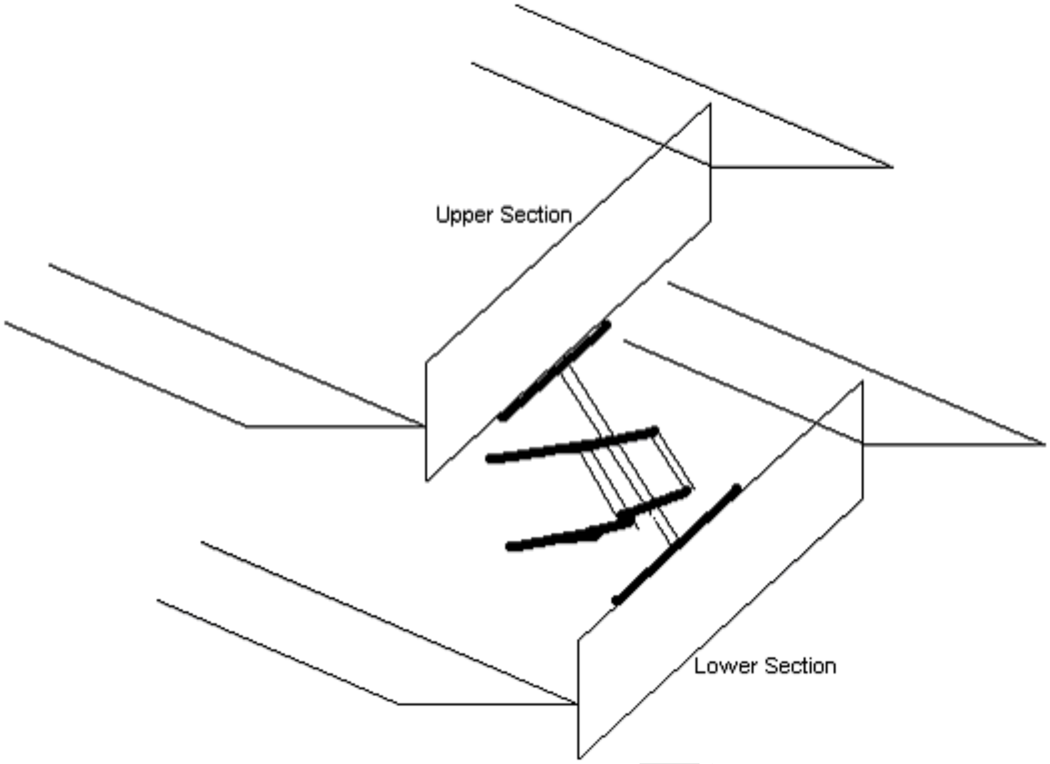
Creep → For loads acting over a long period of time and its high temparature a continuous deformation known as creep takes place. The magnitude of this creep rate diminish as the stress decreases but there is no conclusive evidence that it will ever vanish.

2. Endurance Limit → Every part of the structure has a designed life time after which it should be replaced. This time period for which a component is used in operational work without any chance of failure is known as endurance limit.

   For safety precaution component is replaced well before its endurance limit.

2. Safe Life Concept → Every part of aircraft mentions ita safe life period for which they will work without showing any sign of fatigue, corrosion or damage. This showing time is expressed in terms of number of flying hours, number of flights or number of applications of loads. This life is calculated after much testing and experiments and testing condition is also evaluated with operating conditions before reaching at conclusion.

   During this period, chances of failure are very less and new parts replace old parts well before the indicated period to ensure safely.



3. Basic Defination →

i> A simple structure is made up of three types of members that is beams, struts and ties.

A members subjected to bending is known as a beam, one subjected to compression as a strut and one subjected to tension is known as a tie.

ii> Stress = Force / Area , Strain = Change of Length / Original Length

iii> Ultimate Strength → The maximum strength a member can withstand is known as ultimate strength It is of the types

Ultimate Tensile Strength → It concerns with the maximum tension.

Ultimate Compressive Strength → It concerns with the maximum compression.

iv> Elastic limit → It is the maximum load a material can carry without losing its elasticity.

It means if load is applied within this limit then body may deform at application of load but deformation vanishes at the removal of loads, and body retains its original shape.

v> Factor of Safety or Safety Factor → It is relationship between the strength of a member necessary to carry the working load and its ultimate strength is known as factor of safety.

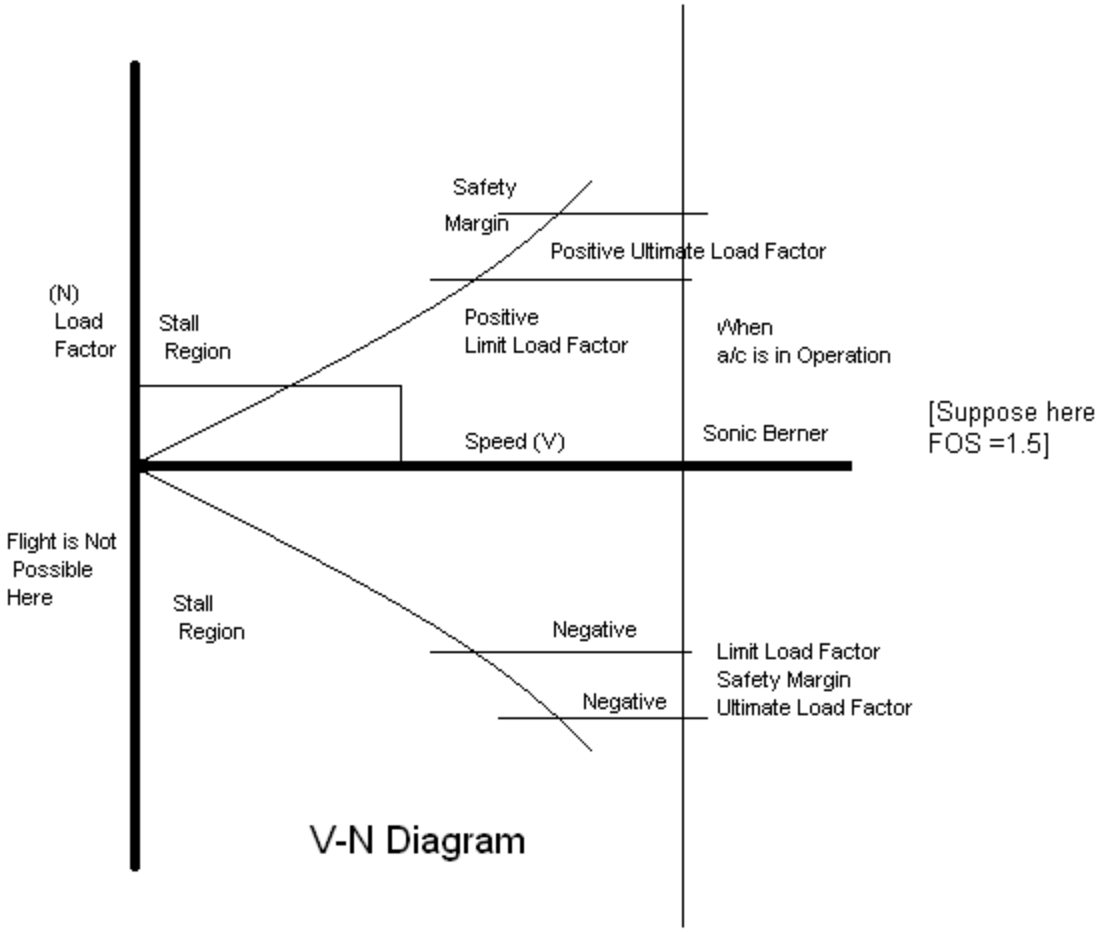
$$FOS = \frac{\text{Ultimate Strength}}{\text{Working Load}}$$

5. Flight Envelop for velocity and load factor is known as V-N diagram.

V-N diagram gives relationship between velocity and load factor.

$$\text{Load Factor (N)} = \frac{L}{W} = \frac{\frac{1}{2} \rho V^2 S C_l}{W}$$

$$N \propto V^2$$



Each Aircraft has its own particular V-N diagram with specific velocities and load factors.

The flight operating strength of an airplane is presented on a graph whose horizontal scale is V(speed) and vertical scale is N (Load Factor).

Performance of a/c is limited by positive and negative ultimate limits. When the a/c operates beyond this region, structural damage occurs causing crash.

Also a/c cant operate beyond this curve because they are assigned as stall region i.e. speed beyond this curve is not enough to maintain straight and level flight. In stall region great structural damage occurs.

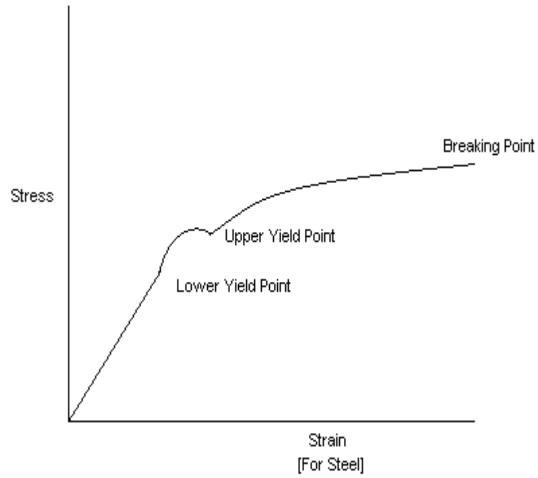
6. Stress-Strain diagram for Al and Steel.

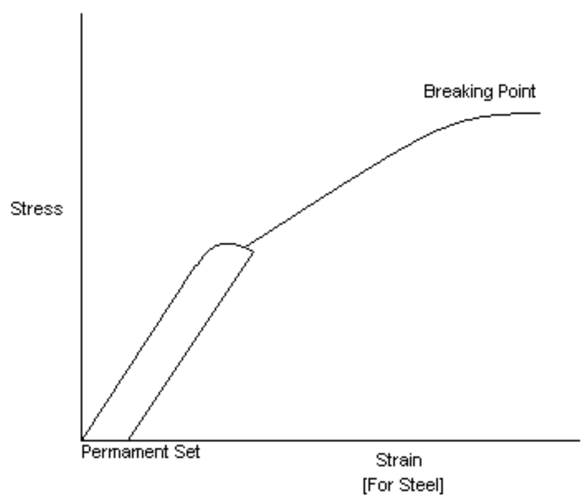
When load is applied on steel piece it deforms within elastic limit this deformation is not permanent and with the removal of lands it again reduces to its original length.

If load is further increased beyond elastic limit it cant return to its original position, the point where this permanent deformation starts is known as yield point (lower yield point). After upper yield point the piece elongation reaches upto breaking point. Here stress doesnt increase much but strain increases significantly.

For the Al when the load is applied within the elastic limit it deforms but return to its original position at the removal of loads. But when the stress exceeds point P the material is in plastic state and if the load is taken off it does not come to its original (zero) position, but at some point S where stress is zero but strain is not zero but strain is not zero. This retained extension is known as permanent set.

This increases the stress level of Al and with improved charecteristics and it makes the Al piece more work hardened.





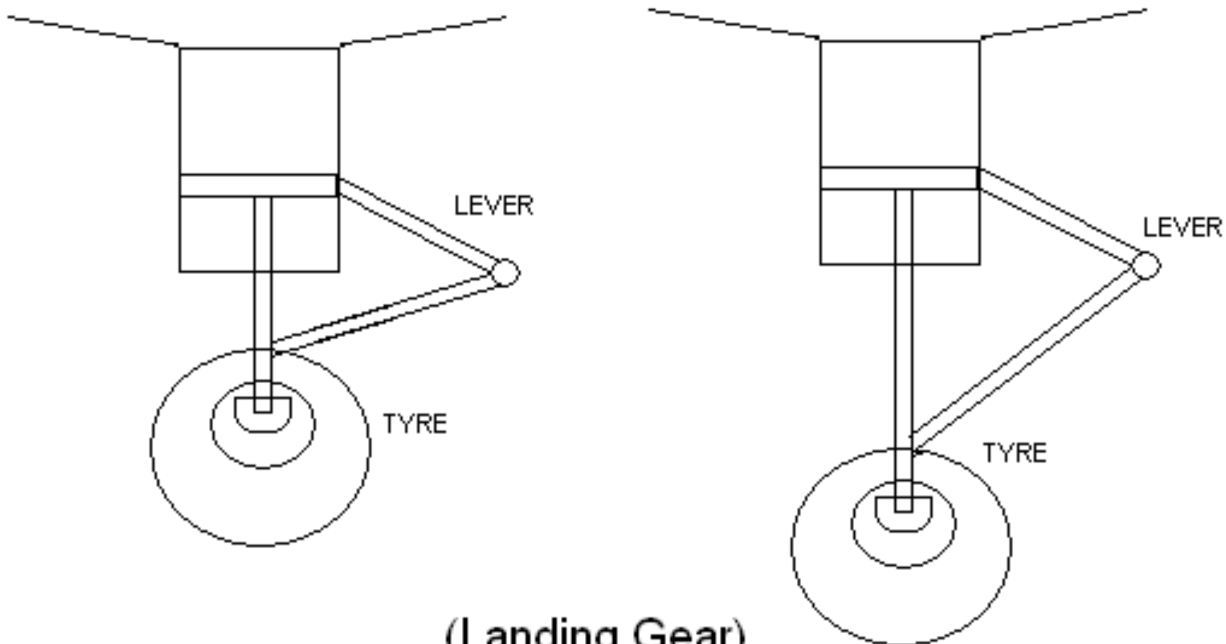
7. Landing Gear → It transmits landing loads to the a/c without overstressing any portions of the a/c structure.

In an a/c two landing gears are used generally one below the main body and the second below the nose.

i> Landing gear located below the main body is known as 'Main Landing Gear' (MLG).

When an aircraft lands, it strikes the ground with a reasonable high speed and at that time all loads of a/c concentrates on it. Therefore it should be very strong in strength and important from structural point of view.

ii> Nose Landing Gear (NLG) is located below the cockpit or nose of a/c, it is relatively less strong than MLG. It carries the load of plane when it tries to stablize after the landing to horizontal position. (According to operation landing gears are classified as fixed type and retractable type.)



(Landing Gear)