A Project Report on

DESIGN OF BABY ACE AIRCRAFT

Submitted in partial fulfilling of the requirements for the

Academic requirements for the award of

Degree of Bachelor of Technology

In

MECHANICAL ENGINEERING

(2009-2013)

By

T.V.K SUBHASH	09311A03A3
K.SANTHOSH KUMAR	09311A03B4
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Department of Mechanical Engineering

SREENIDHI INSTITUTE OF SCIENCE AND TECHNOLOGY

Yamnampet, Ghatkesar Mandal, R.R. District, Hyderabad-501301

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CERTIFICATE

This is to certify that the project report on "**DESIGN OF BABY ACE AIRCRAFT**", submitted by T.V.K.Subhash (09311A03A3), K.Santhosh Kumar (09311A03B4) and S.Santhosh Kumar (09311A03B5) in partial fulfillment of the academic requirements of Jawaharlal Nehru Technology University for the award of the degree of Bachelor of Technology in Mechanical Engineering during the year 2009-2013, is a bonafide work that has been carried out by them under our guidance. This report has not been submitted to any other institute or university for the ward of any degree.

Mr. V.Sateesh kumar	Dr.T.Ch. Siva Reddy
Assistant Professor	Professor & Head
Internal Guide	Dept. of Mechanical Engineering

DECLARATION

This is to certify that the work reported in the present thesis titled **“DESIGN OF BABY ACE AIRCRAFT”** is a record work done by me/us in the **Department of Mechanical Engineering, Sreenidhi Institute of Science and Technology, Yamnampet, Ghatkesar.**

No part of the thesis is copied from books/ journals and wherever the portion is taken, the same has been duly referred in the text. The report is based on the project work done entirely by me/ us and not copied from any other source.

T.V.K Subhash

K.Santhosh Kumar

S.Santhosh Kumar

ACKNOWLEDGEMENTS

The satisfaction and euphoria that accompanies the successful completion of any task would be incomplete without mentioning the people who made it possible, because success is the epitome of hard work, perseverance, undeterred missionary zeal, steadfast determination and most of all encouraging guidance.

We express our gratitude to our institution SREENIDHI INSTITUTE OF SCIENCE AND TECHNOLOGY, GHATKESAR for providing us the means of attaining our goals.

We are greatly thankful to Mr.Ravinder reddy who was instrumental in making of this project. We are deeply indebted to them, who spared their most valuable time for the continuous improvement of the work from time to time.

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Finally we thank our parents for their whole hearted support in this endeavor

T.V.K Subhash

K.Santhosh Kumar

S.Santhosh Kumar

Abstract

Baby ace is an air craft which is popular single seater air craft simple in construction. The project started on 4th of January. It took four months to make our dream into the practical project.

The Baby Ace world, but the Ace is similar in concept to the Fly Baby (single seat, A38-powered, closed cockpit, simple aircraft).

The value of partially-completed Fly Baby/Baby Ace, etc. is greatly driven by the other components included in other words, not just the completed structure, but items such as:

1. The engine (depends greatly on condition and type)
2. Wheels, tires, and brakes (brand-new)
3. Hardware such as strut fittings
4. Propeller
5. Instruments
6. Tail wheel assembly
7. Major components such as the wing spars
8. Suspension

The goodies listed above have their own value, though. The level of completion will affect the value of the project, but that's hard to assess for a simple plans-built aircraft like the Ace.

Unlike other Baby Ace our project suspension is a bit different, innovative and simple in construction meeting the real world applications which is different from other baby air craft. Two springs supported by two nylon seats above and below on either side of the boot space of the cockpit, which yields the best suspension.

Aspects considered in designing the suspension:

- Load
- Space
- Linkage
- Unsprung mass
- Sprung mass
- Material consideration

The other important aspect to be considered in the project is ENGINE. Most of the baby aces uses air craft I.C. engine (horizontal inline engine). For the first time we are using an automobile engine (two cylinder vertical inline engine)

CONTENTS:

TABLE OF FIGURES:

List of Graphs:

1.INTRODUCTION

1.1 Introduction to Airplane Flight Mechanics:

How Air planes Fly:

Almost everyone today has flown in an airplane. Many ask the simple question "what makes an airplane fly"? The answer one frequently gets is misleading and often just plain wrong. We hope that the answers provided here will clarify many misconceptions about lift and that you will adopt our explanation when explaining lift to others. We are going to show you that lift is easier to understand if one starts with Newton rather than Bernoulli. We will also show you that the popular explanation that most of us were taught is misleading at best and that lift is due to the wing diverting air down.

Let us start by defining three descriptions of lift commonly used in textbooks and training manuals. The first we will call the Mathematical Aerodynamics Description which is used by aeronautical engineers. This description uses complex mathematics and/or computer simulations to calculate the lift of a wing. These are design tools which are powerful for computing lift but do not lend themselves to an intuitive understanding of flight.

The second description we will call the Popular Explanation which is based on the Bernoulli principle. The primary advantage of this description is that it is easy to understand and has been taught for many years. Because of its simplicity, it is used to describe lift in most flight training manuals. The major disadvantage is that it relies on the "principle of equal transit times" which is wrong. This description focuses on the shape of the wing and prevents one from understanding such important phenomena as inverted flight, power, ground effect, and the dependence of lift on the angle of attack of the wing.

The third description, which we are advocating here, we will call the Physical Description of lift. This description is based primarily on Newton’s laws. The physical description is useful for understanding flight, and is accessible to all that are curious. Little math is needed to yield an estimate of many phenomena associated with flight. This description gives a clear, intuitive understanding of such phenomena as the power curve, ground effect, and high-speed stalls. However, unlike the mathematical aerodynamics description, the physical description has no design or simulation capabilities.

1.2 Air Craft Mechanics:

A force may be thought of as a push or pull in a specific direction. A force is a vector quantity so a force has both a magnitude and a direction. When describing forces, we have to specify both the magnitude and the direction. This slide shows the forces that act on an airplane in flight.

Weight:

Weight is a force that is always directed toward the center of the earth. The magnitude of the weight depends on the mass of all the airplane parts, plus the amount of fuel, plus any payload on board (people, baggage, freight, etc.). The weight is distributed throughout the airplane. But we can often think of it as collected and acting through a single point called the center of gravity. In flight, the airplane rotates about the center of gravity.

Flying encompasses two major problems; overcoming the weight of an object by some opposing force, and controlling the object in flight. Both of these problems are related to the object's weight and the location of the center of gravity. During a flight, an airplane's weight constantly changes as the aircraft consumes fuel. The distribution of the weight and the center of gravity also changes. So the pilot must constantly adjust the controls to keep the airplane balanced, or trimmed.

Lift:

To overcome the weight force, airplanes generate an opposing force called lift. Lift is generated by the motion of the airplane through the air and is an aerodynamic force. "Aero" stands for the air, and "dynamic" denotes motion. Lift is directed perpendicular to the flight direction. The magnitude of the lift depends on several factors including the shape, size, and velocity of the aircraft. As with weight, each part of the aircraft contributes to the aircraft lift force. Most of the lift is generated by the wings. Aircraft lift acts through a single point called the center of pressure. The center of pressure is defined just like the center of gravity, but using the pressure distribution around the body instead of the weight distribution.

The distribution of lift around the aircraft is important for solving the control problem. Aerodynamic surfaces are used to control the aircraft in roll, pitch, and yaw.

Drag:

As the airplane moves through the air, there is another aerodynamic force present. The air resists the motion of the aircraft and the resistance force is called drag. Drag is directed along and opposed to the flight direction. Like lift, there are many factors that affect the magnitude of the drag force including the shape of the aircraft, the "stickiness" of the air, and the velocity of the aircraft. Like lift, we collect all of the individual components' drags and combine them into a single aircraft drag magnitude. And like lift, drag acts through the aircraft center of pressure.

Thrust:

To overcome drag, airplanes use a propulsion system to generate a force called thrust. The direction of the thrust force depends on how the engines are attached to the aircraft. In the figure shown above, two turbine engines are located under the wings, parallel to the body, with thrust acting along the body centerline. On some aircraft, such as the Harrier, the thrust direction can be varied to help the airplane take off in a very short distance. The magnitude of the thrust depends on many factors associated with the propulsion system including the type of engine, the number of engines, and the throttle setting.

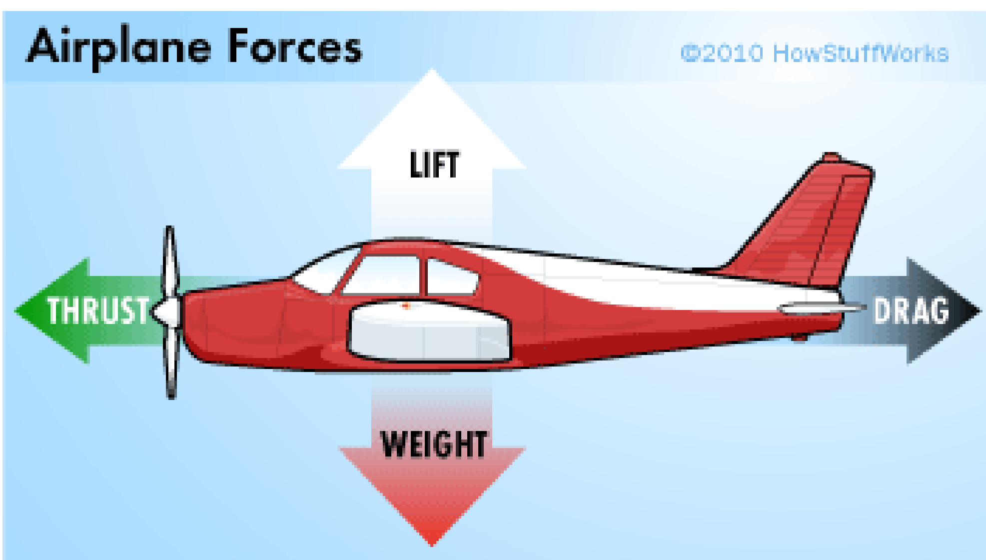


Fig 1.1: FORCES ACTING ON A AIRCRAFT

1.3 The Popular explanation of lift:

Students of physics and aerodynamics are taught that airplanes fly as a result of Bernoulli’s principle, which says that if air speeds up the pressure is lowered. Thus a wing generates lift because the air moves faster over the top creating a region of low pressure, and thus lifts. This explanation usually satisfies the curious and few challenge the conclusions. Some may wonder why the air goes faster over the top of the wing and this is where the popular explanation of lift falls apart.

In order to explain why the air goes faster over the top of the wing, many have resorted to the geometric argument that the distance the air must travel is directly related to its speed. The usual claim is that when the air separates at the leading edge, the part that goes over the top must converge at the trailing edge with the part that goes under the bottom. This is the so-called "principle of equal transit times".

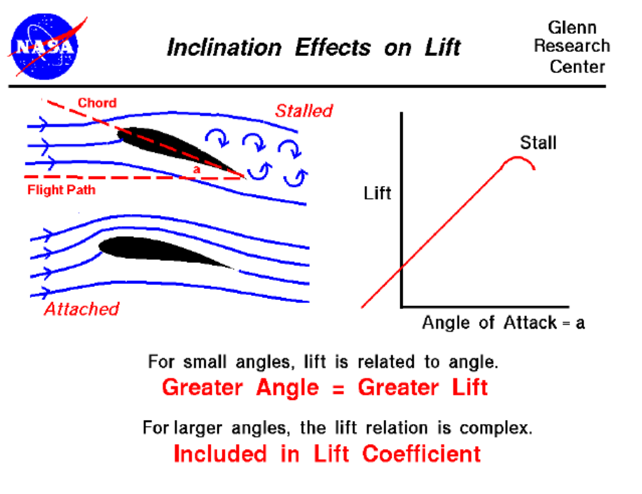


Fig 1.2 Inclination effects on Lift

As discussed by Gale Craig (Stop Abusing Bernoulli! How Airplanes Really Fly., Regenerative Press, Anderson, Indiana, 1997), let us assume that this argument were true. The average speeds of the air over and under the wing are easily determined because we can measure the distances and thus the speeds can be calculated. From Bernoulli’s principle, we can then determine the pressure forces and thus lift. If we do a simple calculation we would find that in order to generate the required lift for a typical small airplane, the distance over the top of the wing must be about 50% longer than under the bottom. Figure 1.3 shows what such an airfoil would look like. Now, imagine what a Boeing 747 wing would have to look like.

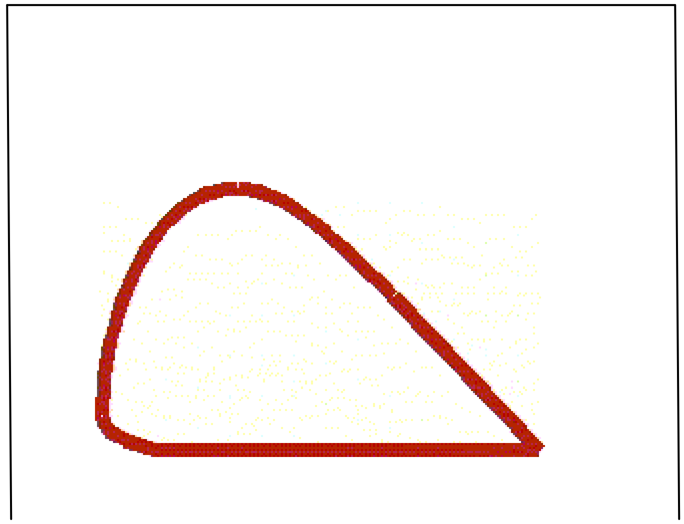


Fig 1.3 Shape of wing predicted by principle of equal transit time.

If we look at the wing of a typical small plane, which has a top surface that is 1.5 - 2.5% longer than the bottom, we discover that a Cessna 172 would have to fly at over 400 mph to generate enough lift. Clearly, something in this description of lift is flawed.

But, who says the separated air must meet at the trailing edge at the same time? Figure 1.4 shows the airflow over a wing in a simulated wind tunnel. In the simulation, colored smoke is introduced periodically. One can see that the air that goes over the top of the wing gets to the trailing edge considerably before the air that goes under the wing. In fact, close inspection shows that the air going under the wing is slowed down from the "free-stream" velocity of the air. So much for the principle of equal transit times.

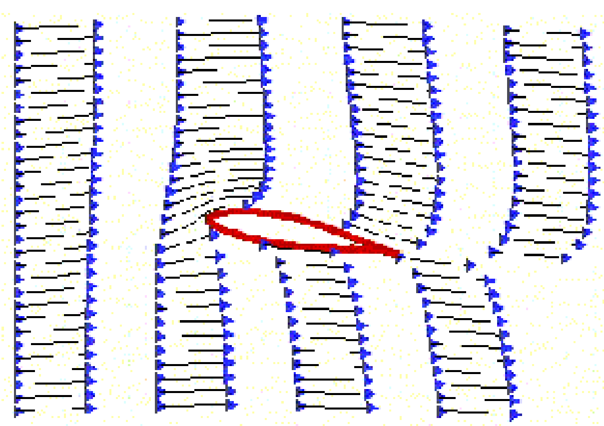


Fig 1.4 Simulation of the airflow over a wing in a wind tunnel, with colored "smoke" to show the acceleration and deceleration of the air.

The popular explanation also implies that inverted flight is impossible. It certainly does not address acrobatic airplanes, with symmetric wings (the top and bottom surfaces are the same shape), or how a wing adjusts for the great changes in load such as when pulling out of a dive or in a steep turn?

So, why has the popular explanation prevailed for so long? One answer is that the **Bernoulli principle** is easy to understand. There is nothing wrong with the Bernoulli principle, or with the statement that the air goes faster over the top of the wing. But, as the above discussion suggests, our understanding is not complete with this explanation. The problem is that we are missing a vital piece when we apply Bernoulli's principle. We can calculate the pressures around the wing if we know the speed of the air over and under the wing, but how do we determine the speed?

Another fundamental shortcoming of the popular explanation is that it ignores the work that is done. Lift requires power (which is work per time). As will be seen later, an understanding of power is key to the understanding of many of the interesting phenomena of lift

1.4 Newton's laws and lift:

So, how does a wing generate lift? To begin to understand lift we must return to high school physics and review Newton's first and third laws. (We will introduce Newton's second law a little later.) Newton's first law states a body at rest will remain at rest or a body in motion will continue in straight-line motion unless subjected to an external applied force. That means, if one sees a bend in the flow of air, or if air originally at rest is accelerated into motion, there is force acting on it. Newton's third law states that for every action there is an equal and opposite reaction. As an example, an object sitting on a table exerts a force on the table (its weight) and the table puts an equal and opposite force on the object to hold it up. In order to generate lift a wing must do something to the air. What the wing does to the air is the action while lift is the reaction.

Let's compare two figures used to show streams of air (streamlines) over a wing. In figure 1.5 the air comes straight at the wing, bends around it, and then leaves straight behind the wing. We have all seen similar pictures, even in flight manuals. But, the air leaves the wing exactly as it appeared ahead of the wing. There is no net action on the air so there can be no lift! Figure 1.6 shows the streamlines, as they should be drawn. The air passes over the wing and is bent down. The bending of the air is the action. The reaction is the lift on the wing.

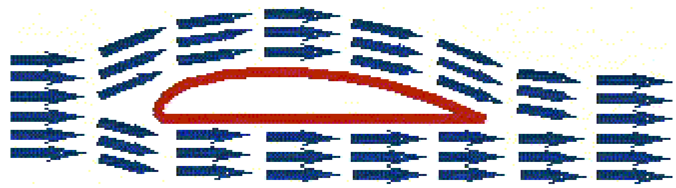


Fig 1.5 Common depiction of airflow over a wing. This wing has no lift.

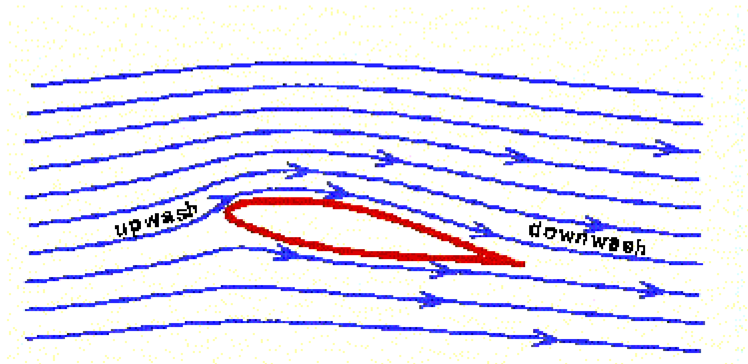


Fig 1.6 True airflow over a wing with lift, showing upwash and downwash.

A region of lower-than-normal air pressure is generated over the top surface of the wing, with a higher pressure existing on the bottom of the wing. These air pressure differences can be either measured directly using instrumentation or they can be calculated from the airspeed distribution using basic physical principles, including Bernoulli's Principle which relates changes in air speed to changes in air pressure.

2.PROPELLER

Thrust is the force that moves the aircraft through the air. Thrust is generated by the propulsion system of the aircraft. There are different types of propulsion systems develop thrust in different ways, although it usually generated through some application of Newton's Third Law. Propeller is one of the propulsion system. The purpose of the propeller is to move the aircraft through the air. The propeller consist of two or more blades connected together by a hub. The hub serves to attach the blades to the engine shaft.

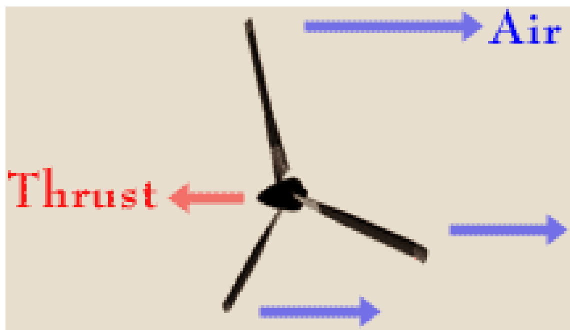


Fig 2.1: Propeller

2.1 Description

Leading Edge of the airfoil is the cutting edge that slices into the air. As the leading edge cuts the air, air flows over the blade face and the cambe side.

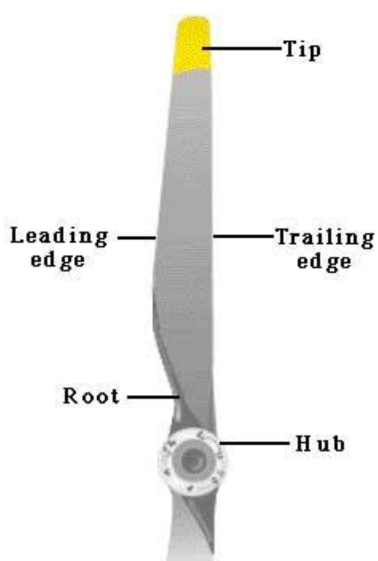


Fig 2.2: Propeller nomenclature

Blade Face is the surface of the propeller blade that corresponds to the lower surface of an airfoil or flat side, we called Blade Face.

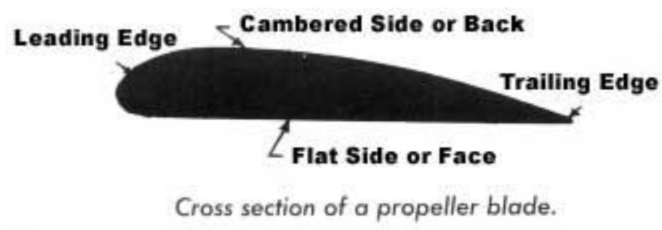


Fig 2.3: Blade Back / Thrust Face is the curved surface of the airfoil.

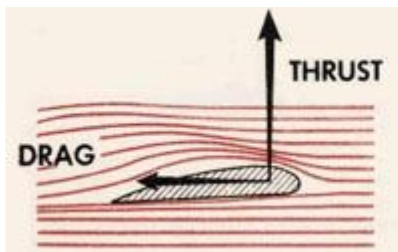


Fig 2.4: Blade Shank (Root) is the section of the blade nearest the hub.

Blade Tip is the outer end of the blade farthest from the hub

Plane of Rotation is an imaginary plane perpendicular to the shaft. It is the plane that contains the circle in which the blades rotate.

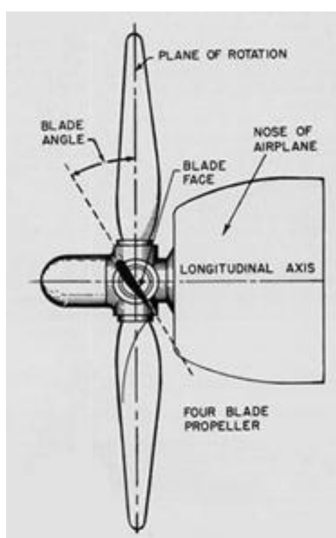


Fig 2.5: propeller plane of rotation

Blade Angle is formed between the face of an element and the plane of rotation. The blade angle throughout the length of the blade is not the same. The reason for placing the blade element sections at different angles is because the various sections of the blade travel at different speed. Each element must be designed as part of the blade to operate at its own best angle of attack to create thrust when revolving at its best design speed.

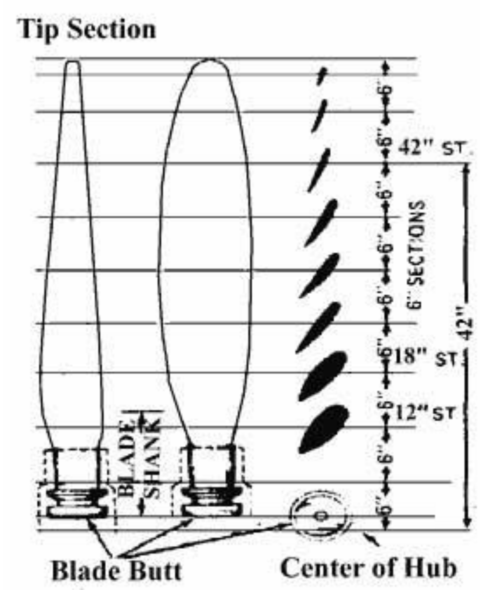


Fig 2.6 Propeller blade profile

Blade Element are the airfoil sections joined side by side to form the blade airfoil. These elements are placed at different angles in rotation of the plane of rotation.

The reason for placing the blade element sections at different angles is because the various sections of the blade travel at different speeds. The inner part of the blade section travels slower than the outer part near the tip of the blade. If all the elements along a blade is at the same blade angle, the relative wind will not strike the elements at the same angle of attack. This is because of the different in velocity of the blade element due to distance from the center of rotation.

The blade has a small twist (due to different angle in each section) in it for a very important reason. When the propeller is spinning round, each section of the blade travel at different speed, The twist in the propeller blade means that each section advance forward at the same rate so stopping the propeller from bending.

Thrust is produced by the propeller attached to the engine driveshaft. While the propeller is rotating in flight, each section of the blade has a motion that combines the forward motion of the aircraft with circular movement of the propeller.

The slower the speed, the steeper the angle of attack must be to generate lift. Therefore, the shape of the propeller's airfoil (cross section) must change from the center to the tips. The changing shape of the airfoil (cross section) across the blade results in the twisting shape of the propeller.

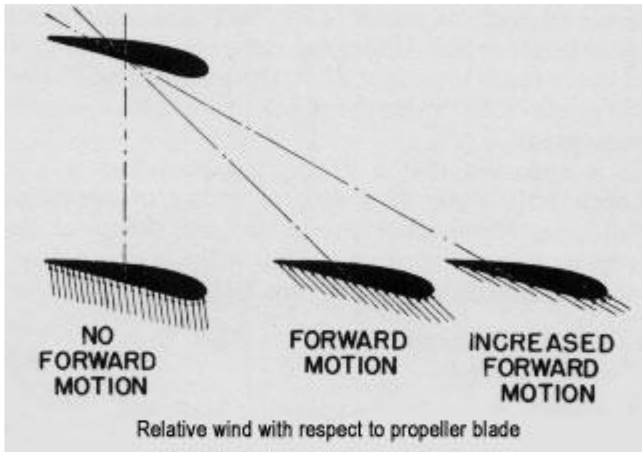


Fig 2.7: Relative wind with respect to propeller blade

Relative Wind is the air that strikes and passes over the airfoil as the airfoil is driven through the air.

Angle of Attack is the angle between the chord of the element and the relative wind. The best efficiency of the propeller is obtained at an angle of attack around 2 to 4 degrees.

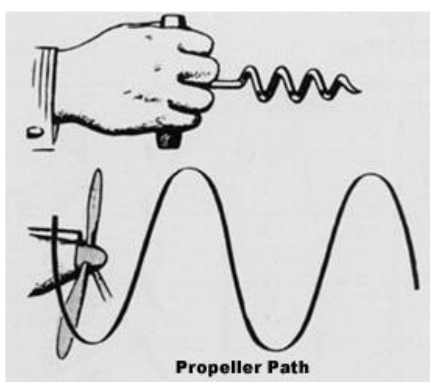


Fig 2.8 Propeller path

Pitch refers to the distance a spiral threaded object moves forward in one revolution. As a wood screw moves forward when turned in wood, same with the propeller move forward when turn in the air.

Geometric Pitch is the theoretical distance a propeller would advance in one revolution.

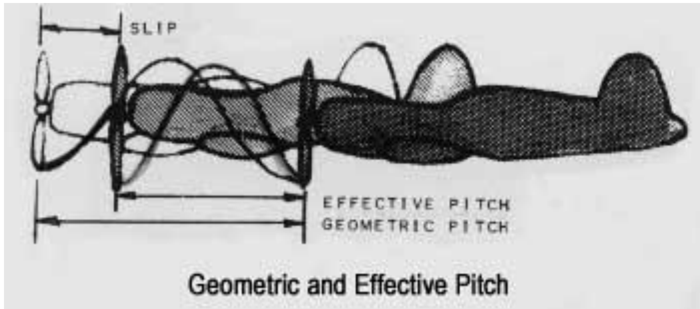


Fig 2.9 Geometric and element pitch

Effective Pitch is the actual distance a propeller advances in one revolution in the air. The effective pitch is always shorter than geometric pitch due to the air is a fluid and always slip.

2.2 Forces and stresses acting on a propeller in flight

The forces acting on a propeller in flight are :

1. Thrust is the air force on the propeller which is parallel to the direction of advance and induces bending stress in the propeller.

2. Centrifugal force is caused by rotation of the propeller and tends to throw the blade out from the center.

3. Torsion or Twisting forces in the blade itself, caused by the resultant of air forces which tend to twist the blades toward a lower blade angle.

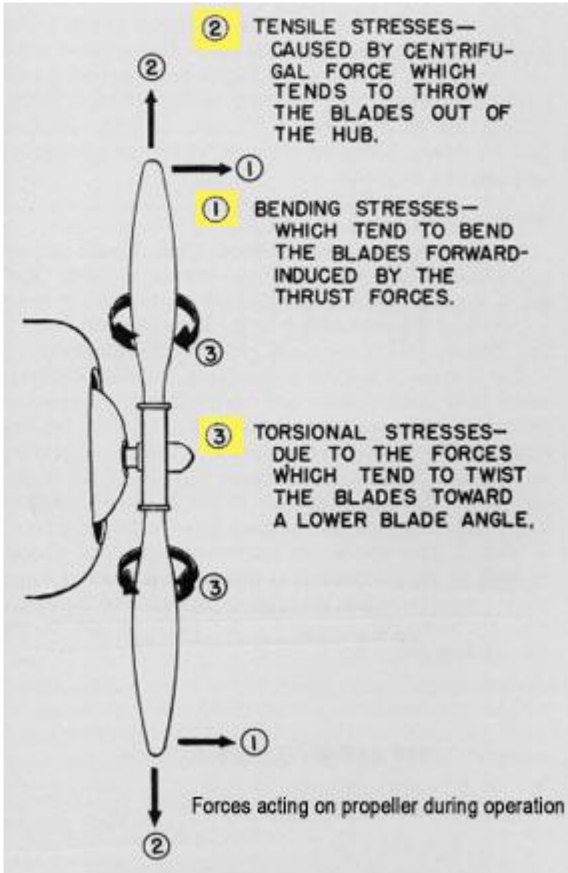


Fig 2.10: Forces acting on propeller during operation

The stress acting on a propeller in flight are :

1. Bending stresses are induced by the trust forces. These stresses tend to bend the blade forward as the airplane is moved through the air by the propeller.

2. Tensile stresses are caused by centrifugal force.

3. Torsion stresses are produced in rotating propeller blades by two twisting moments. one of these stresses is caused by the air reaction on the blades and is called the aerodynamic twisting moment. The another stress is caused by centrifugal force and is called the centrifugal twisting moment.

3.ENGINE

An **aircraft engine** is the component of the propulsion system for an aircraft that generates mechanical power. Aircraft engines are almost always either lightweight piston engines or gas turbines.

3.1 Different types of Engines used in aircrafts are:

1).Shaft Engines:

a) Reciprocating piston Engines

i) In-line Engines

ii) V-type Engines

iii) Horizontally Opposed Engine

iv) Radial Engines

v) Rotary Engines

b) Turbine-Powered

i) Turboprop

ii) Turboshaft

2) Reaction Engines:

a) Jets

i) Turbojet

ii) Turbofan

b) Pulse Jet

c) Rocket

3) Newer engine types

a) Wankel Engine

b) Diesel Engine

c) Precooled jet engines

d) Electric

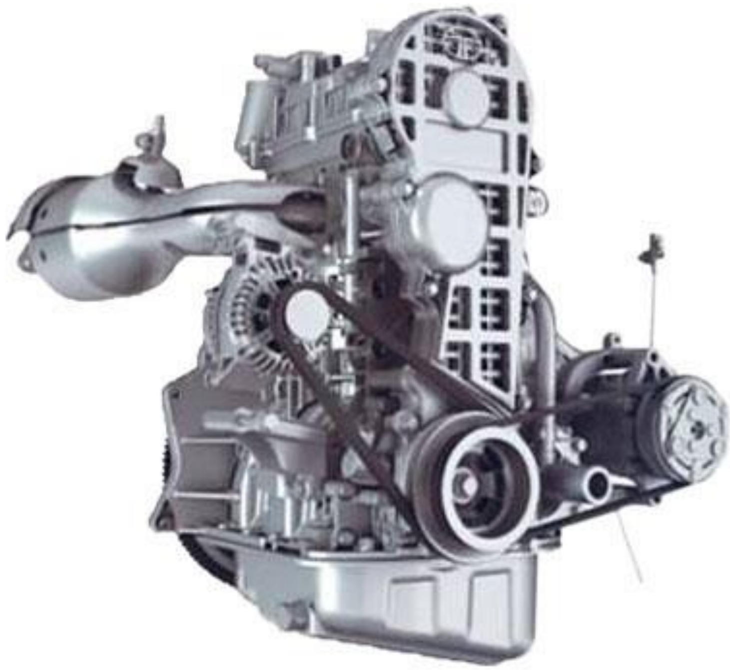


Fig 3.1: Tata nano engine

Technical Specifications

Details	**Nano**
DIMENSIONS	
ENGINE & TRANSMISSION	
Engine Type	624 cc, 2 cylinder, MPFI
Maximum Engine Output	38 PS @ 5500 ± 250 rpm
Maximum Torque	51 Nm @ 4000 ± 500 rpm

Fig 3.2: Technical specifications of TATA NANO engine

3.2 In-line Engine:

This type of engine has cylinders lined up in one row. It typically has an even number of cylinders, but there are instances of three- and five- cylinder engines. The biggest advantage of an inline engine is that it allows the aircraft to be designed with a narrow frontal area for low drag. If the engine crankshaft is located above the cylinders, it is called an inverted inline engine, which allows the propeller to be mounted up high for ground clearance even with short landing gear. The disadvantages of an inline engine include a poor power-to-weight ratio, because the crankcase and crankshaft are long and thus heavy. An in-line engine may be either air-cooled or liquid-cooled, but liquid-cooling is more common because it is difficult to get enough air-flow to cool the rear cylinders directly. Inline engines were common in early aircraft, including the Wright Flyer, the aircraft that made the first controlled powered flight. However, the inherent disadvantages of the design soon became apparent, and the inline design was abandoned, becoming a rarity in modern aviation.

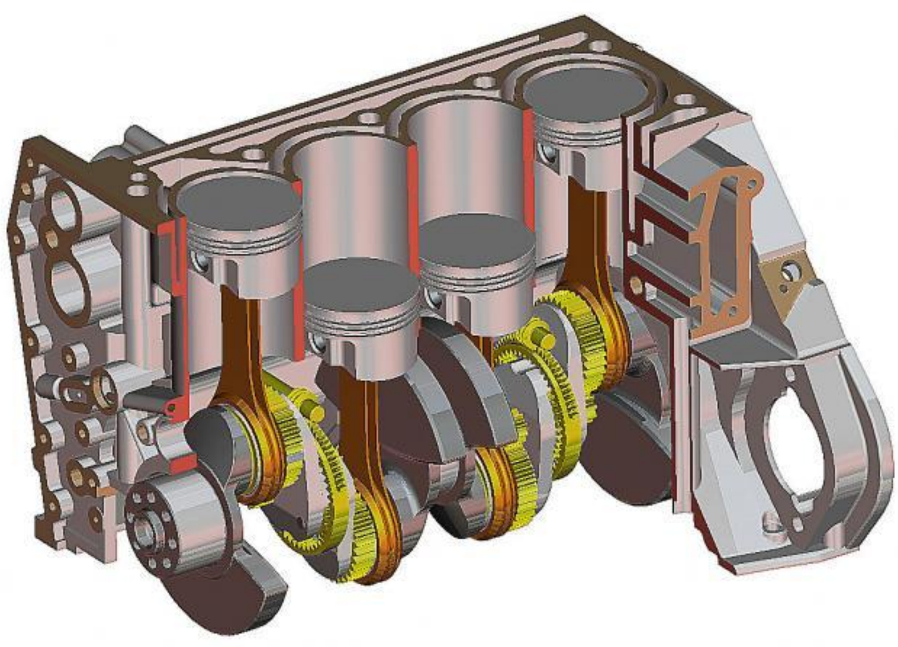
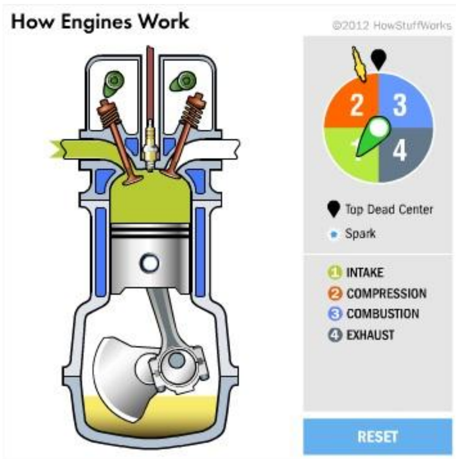
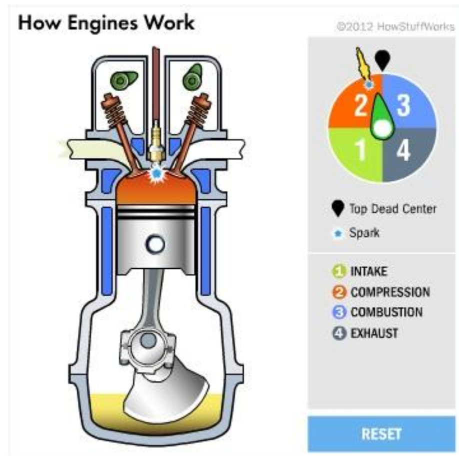


Fig 3.3 Inline Engine

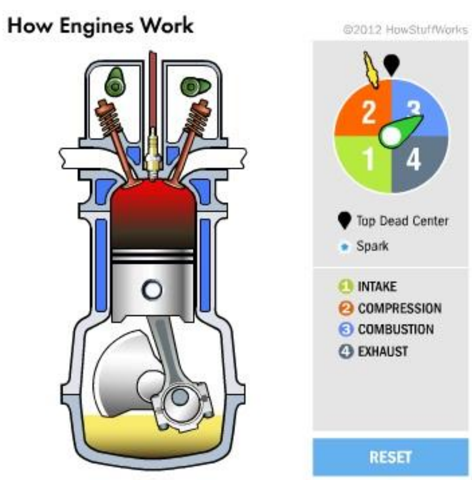
3.3 <u>Principle of an I.C Engine:</u>



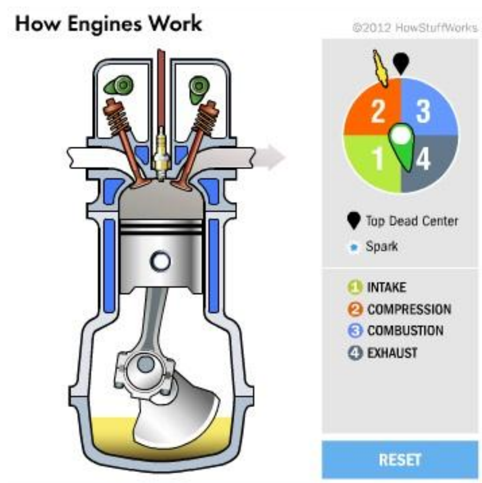
1.Intake



2.Compression



3.Combustion



4.Exhaust

Fig 3.4 Different strokes in 4-stroke S.I engine

The principle behind any reciprocating internal combustion engine: If you put a tiny amount of high-energy fuel (like gasoline) in a small, enclosed space and ignite it, an incredible amount of energy is released in the form of expanding gas. You can use that energy to propel a potato 500 feet. In this case, the energy is translated into potato motion. You can also use it for more interesting purposes. For example, if you can create a cycle that allows you to set off explosions like this hundreds of times per minute, and if you can harness that energy in a useful way, what you have is the core of a car engine!

Almost all cars currently use what is called a **four-stroke combustion cycle** to convert gasoline into motion. The four-stroke approach is also known as the **Otto cycle**, in honor of Nikolaus Otto, who invented it in 1867. The four strokes are illustrated in **Figure** . They are:

- Intake stroke
- Compression stroke
- Combustion stroke
- Exhaust stroke

You can see in the figure that a device called a **piston** replaces the potato in the potato cannon. The piston is connected to the **crankshaft** by a **connecting rod**. As the crankshaft revolves, it has the effect of "resetting the cannon." Here's what happens as the engine goes through its cycle:

1) The piston starts at the top, the intake valve opens, and the piston moves down to let the engine take in a cylinder-full of air and gasoline. This is the **intake stroke**. Only the tiniest drop of gasoline needs to be mixed into the air for this to work. (Part 1 of the figure)

2) Then the piston moves back up to compress this fuel/air mixture. **Compression** makes the explosion more powerful. (Part 2 of the figure)

3) When the piston reaches the top of its stroke, the spark plug emits a spark to ignite the gasoline. The gasoline charge in the cylinder **explodes**, driving the piston down. (Part 3 of the figure)

4) Once the piston hits the bottom of its stroke, the exhaust valve opens and the **exhaust** leaves the cylinder to go out the tailpipe. (Part 4 of the figure)

Now the engine is ready for the next cycle, so it intakes another charge of air and gas.

In this Project Tata Nano Petrol Engine (I.C Engine) is used. To create thrust for the movement of the aircraft the propeller should be rotated at high speeds and the power required to achieve the required rotation speed of propeller should be around 35BHP. So according to these requirements we found out that Nano engine will be sufficient for the aircraft to get the required thrust force.

4. WING DESIGN

A wing is a type of fin with a surface that produces lift for flight or propulsion through the atmosphere, or through another gaseous or liquid fluid. As such, wings have an airfoil shape, a streamlined cross-sectional shape producing a useful lift to drag ratio.

The word "wing" from the Old Norse vangr for many centuries referred mainly to the foremost limbs of birds (in addition to the architectural aisle.) But in recent centuries the word's meaning has extended to include lift producing appendages of insects, bats, pterosaurs, boomerangs, some sail boats and aircraft, or the inverted airfoil on a race car that generates a downward force to increase traction.

The design and analysis of the wings of aircraft is one of the principal applications of the science of aerodynamics, which is a branch of fluid mechanics. The properties of the airflow around any moving object can - in principle - be found by solving the Navier-Stokes equations of fluid dynamics. However, except for simple geometries these equations are notoriously difficult to solve. Fortunately, simpler explanations can be described.

For a wing to produce "lift", it must be oriented at a suitable angle of attack relative to the flow of air past the wing. When this occurs the wing deflects the airflow downwards, "turning" the air as it passes the wing. Since the wing exerts a force on the air to change its direction, the air must exert a force on the wing, equal in size but opposite in direction. This force manifests itself as differing air pressures at different points on the surface of the wing.

A region of lower-than-normal air pressure is generated over the top surface of the wing, with a higher pressure existing on the bottom of the wing. These air pressure differences can be either measured directly using instrumentation or they can be calculated from the airspeed distribution using basic physical principles, including Bernoulli's Principle which relates changes in air speed to changes in air pressure.

The lower air pressure on the top of the wing generates a smaller downward force on the top of the wing than the upward force generated by the higher air pressure on the bottom of the wing. Hence, a net upward force acts on the wing. This force is called the "lift" generated by the wing.

The different velocities of the air passing by the wing, the air pressure differences, the change in direction of the airflow, and the lift on the wing are intrinsically one phenomenon. It is, therefore, possible to calculate lift from any of the other three. For example, the lift can be calculated from the pressure differences, or from different velocities of the air above and below the wing, or from the total momentum change of the deflected air. There are other approaches in fluid dynamics to solving these problems. All of these approaches will result in the same answers if done correctly.

Given a particular wing and its velocity through the air, debates over which mathematical approach is the most convenient to use can be misperceived by novices as differences of opinion about the basic principles of flight.

Devices to change the shape of a wing. Usually, aircraft wings have various devices, such as flaps or slats that the pilot uses to modify the shape and surface area of the wing to change its operating characteristics in flight. In 1948, Francis Rogallo invented the fully limp flexible wing, which ushered new possibilities for aircraft. Near in time, Domina Jalbert invented flexible un-sparred ram-air airfoiled thick wings. These two new branches of wings have been since extensively studied and applied in new branches of aircraft, especially altering the personal recreational aviation landscape.

A common misconception is that in order to generate lift it is essential for the wing to have a longer path on the topside compared with the underside. Wings with this shape are the norm in subsonic flight, but symmetrically shaped wings (above and below) can generate lift by using a positive angle of attack to deflect air downward. Symmetrical aerofoils are, in general, less efficient and lack the lift provided by cambered wings at the zero angle of attack but are used in aerobatics, as they provide practical performance both upright and inverted. Another example comes from sailboats, where the sail is merely a thin membrane and there is no path-length difference between one side and the other.

For flight speeds near the speed of sound (transonic flight) or above the speed of sound (supersonic flight), airfoils with complex asymmetrical shapes are used to minimize the drastic increase in drag associated with airflow near the speed of sound. Such airfoils are called supercritical airfoils.

Airfoil:

An airfoil (in American English) or aerofoil (in British English) is the shape of a wing or blade (of a propeller, rotor, or turbine) or sail as seen in cross-section.

An airfoil-shaped body moved through a fluid produces an aerodynamic force. The component of this force perpendicular to the direction of motion is called lift. The component parallel to the direction of motion is called drag. Subsonic flight airfoils have a characteristic shape with a rounded leading edge, followed by a sharp trailing edge, often with asymmetric camber. Foils of similar function designed with water as the working fluid are called hydrofoils.

The lift on an airfoil is primarily the result of its angle of attack and shape. When oriented at a suitable angle, the airfoil deflects the oncoming air, resulting in a force on the airfoil in the direction opposite to the deflection. This force is known as aerodynamic force and can be resolved into two components: Lift and drag. Most foil shapes require a positive angle of attack to generate lift, but cambered airfoils can generate lift at zero angle of attack. This "turning" of the air in the vicinity of the airfoil creates curved streamlines which results in lower pressure on one side and higher pressure on the other. This pressure difference is accompanied by a velocity difference, via Bernoulli's principle, so the resulting flowfield about the airfoil has a higher average velocity on the upper surface than on the lower surface. The lift force can be related directly to the average top/bottom velocity difference without computing the pressure by using the concept of circulation and the Kutta-Joukowski theorem.

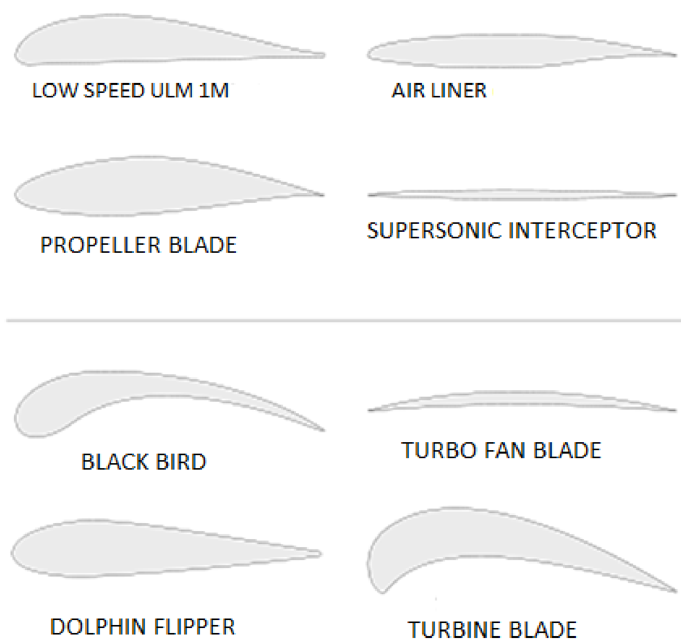


Fig 4.1 Different wing profiles

A fixed-wing aircraft's wings, horizontal, and vertical stabilizers are built with airfoil-shaped cross sections, as are helicopter rotor blades. Airfoils are also found in propellers, fans, compressors and turbines. Sails are also airfoils, and the underwater surfaces of sailboats, such as the centerboard and keel, are similar in cross-section and operate on the same principles as airfoils. Swimming and flying creatures and even many plants and sessile organisms employ airfoils/hydrofoils: common examples being bird wings, the bodies of fish, and the shape of sand dollars. An airfoil-shaped wing can create down force on an automobile or other motor vehicle, improving traction.

Any object with an angle of attack in a moving fluid, such as a flat plate, a building, or the deck of a bridge, will generate an aerodynamic force (called lift) perpendicular to the flow. Airfoils are more efficient lifting shapes, able to generate more lift (up to a point), and to generate lift with less drag.

A lift and drag curve obtained in wind tunnel testing is shown on the right. The curve represents an airfoil with a positive camber so some lift is produced at zero angle of attack. With increased angle of attack, lift increases in a roughly linear relation, called the slope of the lift curve. At about 18 degrees this airfoil stalls, and lift falls off quickly beyond that. The drop in lift can be explained by the action of the upper-surface boundary layer, which separates and greatly thickens over the upper surface at and past the stall angle. The thickened boundary layer's displacement thickness changes the airfoil's effective shape, in particular it reduces its effective camber, which modifies the overall flow field so as to reduce the circulation and the lift. The thicker boundary layer also causes a large increase in pressure drag, so that the overall drag increases sharply near and past the stall point.

Airfoil design is a major facet of aerodynamics. Various airfoils serve different flight regimes. Asymmetric airfoils can generate lift at zero angle of attack, while a symmetric airfoil may better suit frequent inverted flight as in an aerobatic airplane. In the region of the ailerons and near a wingtip a symmetric airfoil can be used to increase the range of angles of attack to avoid spin-stall. Thus a large range of angles can be used without boundary layer separation. Subsonic airfoils have a round leading edge, which is naturally insensitive to the angle of attack. The cross section is not strictly circular, however: the radius of curvature is increased before the wing achieves maximum thickness to minimize the chance of boundary layer separation. This elongates the wing and moves the point of maximum thickness back from the leading edge.

Supersonic airfoils are much more angular in shape and can have a very sharp leading edge, which is very sensitive to angle of attack. A supercritical airfoil has its maximum thickness close to the leading edge to have a lot of length to slowly shock the supersonic flow back to subsonic speeds. Generally such transonic airfoils and also the supersonic airfoils have a low camber to reduce drag divergence. Modern aircraft wings may have different airfoil sections along the wing span, each one optimized for the conditions in each section of the wing.

Movable high-lift devices, flaps and sometimes slats, are fitted to airfoils on almost every aircraft. A trailing edge flap acts similarly to an aileron; however, it, as opposed to an aileron, can be retracted partially into the wing if not used.

A laminar flow wing has a maximum thickness in the middle camber line. Analyzing the Navier-Stokes equations in the linear regime shows that a negative pressure gradient along the flow has the same effect as reducing the speed. So with the maximum camber in the middle, maintaining a laminar flow over a larger percentage of the wing at a higher cruising speed is possible. However, with rain or insects on the wing, or for jetliner speeds, this does not work. Since such a wing stalls more easily, this airfoil is not used on wingtips (spin-stall again).

Schemes have been devised to define airfoils — an example is the NACA system. Various airfoil generation systems are also used. An example of a general purpose airfoil that finds wide application, and predates the NACA system, is the Clark-Y. Today, airfoils can be designed for specific functions using inverse design programs such as PROFOIL, XFOIL and AeroFoil. XFOIL is an online program created by Mark Drela that will design and analyze subsonic isolated airfoils.[5]

4.1 Airfoil terminology:

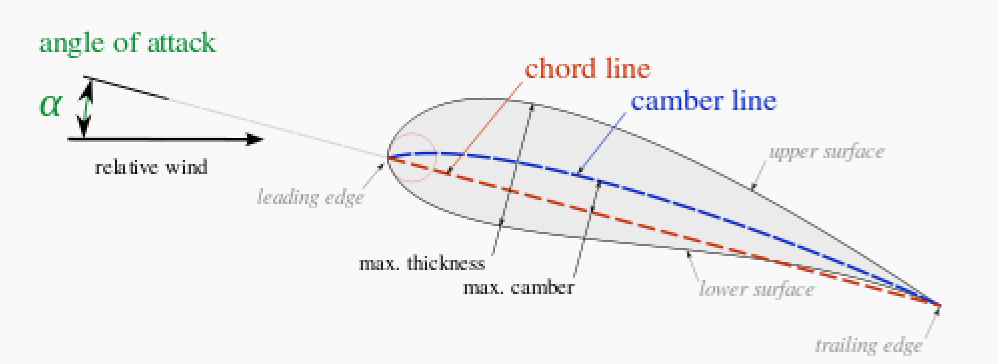


Fig 4.2:Airfoil nomenclature

The various terms related to airfoils are defined below:

- The suction surface (upper surface) is generally associated with higher velocity and lower static pressure.
- The pressure surface (lower surface) has a comparatively higher static pressure than the suction surface. The pressure gradient between these two surfaces contributes to the lift force generated for a given airfoil.

The geometry of the airfoil is described with a variety of terms.

A key characteristic of an airfoil is its chord. We thus define the following concepts:

- The leading edge is the point at the front of the airfoil that has maximum curvature.
- The trailing edge is defined similarly as the point of maximum curvature at the rear of the airfoil.
- The chord line is a straight line connecting the leading and trailing edges of the airfoil.
- The chord length, or simply chord, c, is the length of the chord line and is the characteristic dimension of the airfoil section.

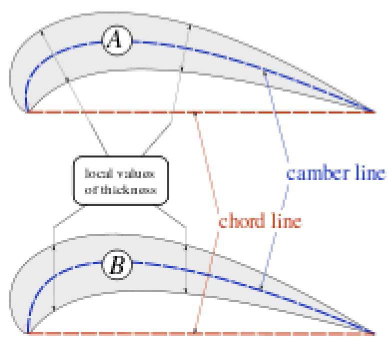


Fig 4.3: Different definitions of airfoil thickness

Fig 4.4An airfoil designed for winglets (PSU 90-125WL)

The shape of the airfoil is defined using the following concepts:

- The mean camber line is the locus of points midway between the upper and lower surfaces. Its exact shape depends on how the thickness is defined.

  The thickness of an airfoil varies along the chord. It may be measured in either of two ways:

- Thickness measured perpendicular to the camber line. This is sometimes described as the "American convention";
- Thickness measured perpendicular to the chord line. This is sometimes described as the "British convention".

Two key parameters to describe an airfoil’s shape are its maximum thickness (expressed as a percentage of the chord), and the location of the maximum thickness point (also expressed as a percentage of the chord).

Finally, important concepts used to describe the airfoil’s behavior when moving through a fluid are:

- The aerodynamic center, which is the chord-wise length about which the pitching moment is independent of the lift coefficient and the angle of attack.
- The center of pressure, which is the chord-wise location about which the pitching moment is zero.

4.2 <u>Angle of Attack:</u>

In fluid dynamics, **angle of attack** (**AOA**, or α (Greek letter alpha)) is the angle between a reference line on a body (often the chord line of an airfoil) and the vector representing the relative motion between the body and the fluid through which it is moving. Angle of attack is the angle between the body's reference line and the oncoming flow. This article focuses on the most common application, the angle of attack of a wing or airfoil moving through air.

In aerodynamics, angle of attack specifies the angle between the chord line of the wing of a fixed-wing aircraft and the vector representing the relative motion between the aircraft and the atmosphere. Since a wing can have twist, a chord line of the whole wing may not be definable, so an alternate reference line is simply defined. Often, the chord line of the root of the wing is chosen as the reference line. Another alternative is to use a horizontal line on the fuselage as the reference line (and also as the longitudinal axis).[2] Some authors[3][4]do not use an arbitrary chord line but use the zero lift axis instead - zero angle of attack corresponds to zero coefficient of lift.

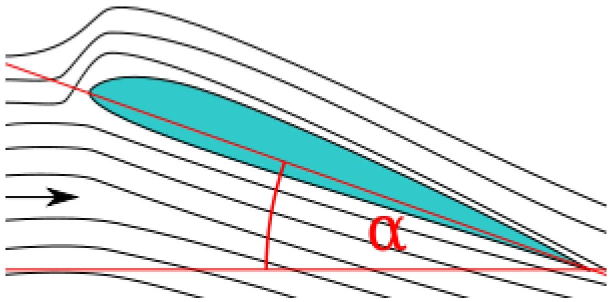


Fig 4.5: Relation between angle of attack and lift

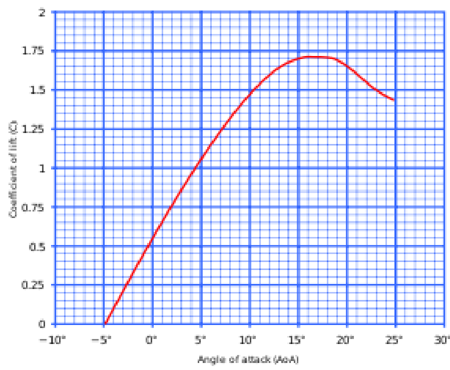


Fig 4.6: A typical lift coefficient curve.

The lift coefficient of a fixed-wing aircraft varies uniquely with angle of attack. Increasing angle of attack is associated with increasing lift coefficient up to the maximum lift coefficient, after which lift coefficient decreases.

As the angle of attack of fixed-wing aircraft increases, separation of the airflow from the upper surface of the wing becomes more pronounced, leading to a reduction in the rate of increase of the lift coefficient. The figure shows a typical curve for a cambered straight wing. A symmetrical wing has zero lift at 0 degrees angle of attack. The lift curve is also influenced by wing planform. A swept wing has a lower flatter curve with a higher critical angle.

4.3 Critical angle of attack

The **critical angle of attack** is the angle of attack which produces maximum lift coefficient. This is also called the "stall angle of attack". Below the critical angle of attack, as the angle of attack increases, the coefficient of lift (Cl) increases. At the same time, above the critical angle of attack, as angle of attack increases, the air begins to flow less smoothly over the upper surface of the airfoil and begins to separate from the upper surface. On most airfoil shapes, as the angle of attack increases, the upper surface separation point of the flow moves from the trailing edge towards the leading edge. At the critical angle of attack, upper surface flow is more separated and the airfoil or wing is producing its maximum coefficient of lift. As angle of attack increases further, the upper surface flow becomes more and more fully separated and the airfoil/wing produces less coefficient of lift.

Above this critical angle of attack, the aircraft is said to be in a stall. A fixed-wing aircraft by definition is stalled at or above the critical angle of attack rather than at or below a particular airspeed. The airspeed at which the aircraft stalls varies with the weight of the aircraft, the load factor, the center of gravity of the aircraft and other factors. However the aircraft always stalls at the same critical angle of attack. The critical or stalling angle of attack is typically around 15° for many airfoils.

5.FUSELAGE

The **fuselage** is an aircraft's main body section that holds crew and passengers or cargo. In single-engine aircraft it will usually contain an engine, although in some amphibious aircraft the single engine is mounted on a pylon attached to the fuselage which in turn is used as a floating hull. The fuselage also serves to position control and stabilization surfaces in specific relationships to lifting surfaces, required for aircraft stability and maneuverability.

Fig 5.1: Fuselage is shown in brown color

The fuselage includes the cabin and/or cockpit, which contains seats for the occupants and the controls for the airplane. In addition, the fuselage may also provide room for cargo and attachment points for the other major airplane components. Some aircraft utilize an open truss structure. The truss-type fuselage is constructed of steel or aluminum tubing. Strength and rigidity is achieved by welding the tubing together into a series of triangular shapes, called trusses.

6. CONTROL SURFACES

Control surface are responsible for the aircraft directional control. The primary parts of control surfaces are

- Rudder
- Elevator
- Horizontal stabilizer
- Vertical stabilizer
- Aileron

The rudder is a movable surface located on the trailing edge of the vertical tail. The rudder is the vertical counterpart to the elevator. When the rudder is rotated, a lift force is created by the rudder vertical tail combination. Consequently, a yawing moment about aircraft center of gravity is generated. Thus, control of the yawing moment about the center of gravity is primarily provided by means of the rudder. The third unintended production of the rudder is a rolling moment. This is due to the fact that the vertical tail (i.e. rudder) is usually placed above the aircraft cg. Two fundamental roles of rudder are directional control and directional trim. Therefore, parameters of the rudder are determined by the directional trim and control requirements.

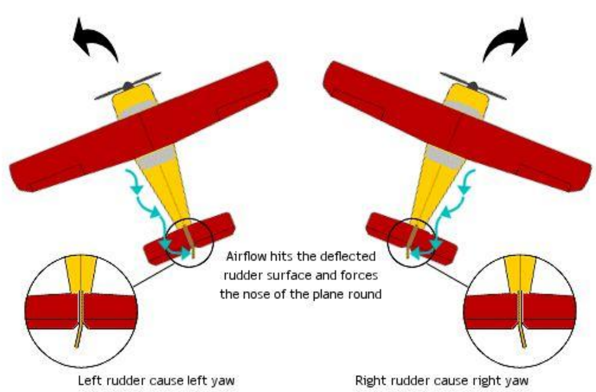


Fig 6.1: Effect of rudder movement

The rudder is attached to the vertical stabilizer. Controlled by the rudder pedals, the rudder is used by the pilot to control the direction (left or right) of yaw about the airplane's vertical axis for minor adjustments. It is NOT used to make the airplane turn, as is often erroneously believed. Banking the airplane makes it turn.

6.1 Axes of rotation:

The airplane can rotate around one, two, or all three axes simultaneously. Think of these axes as imaginary axles around which the airplane turns, much as a wheel would turn around axles positioned in these same three directions.

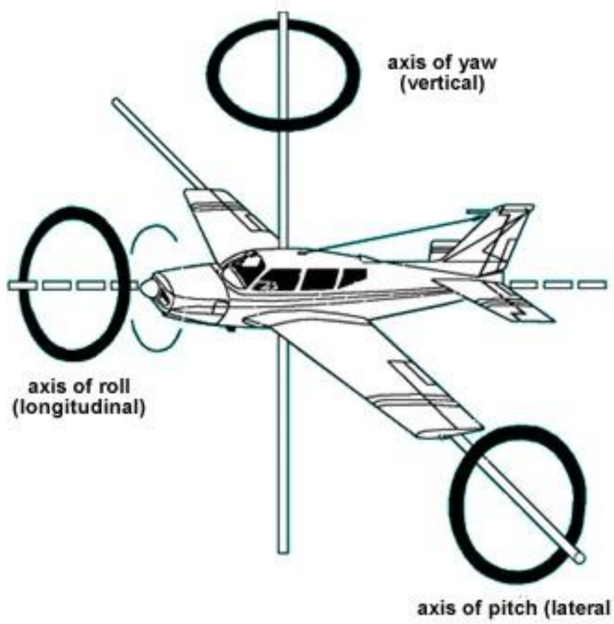


Fig 6.2: Different axes of rotation

Lateral (pitch) axis -- an imaginary line from wingtip to wingtip

- Rotation about the lateral axis is called pitch and is controlled by the **elevator**.
- The rotation is similar to a seesaw. The bar holding the seesaw is the lateral axis.
- This is known as the airplane's pitch attitude.

6.2 Secondary effect of Elevator actuation:

The primary effect is to change the aircraft's pitch. The secondary effect will change the speed. Climbing will slow the plane and descending in increase its speed.

6.3 Elevators:

The control yoke is connected by means of wires, rods or hydraulics to the tail section's elevators. By moving the yoke, the pilot can change the position of the elevators. When the control column is pushed in, the elevators move down, pitching the tail of the airplane up and the nose down, rolling the airplane down. When pulling the control column back makes the elevators move up, bringing the tail of the airplane down and the nose up, pitching the airplane upwards.

Longitudinal (roll) axis -- an imaginary line from the nose to the tail

- Rotation about the longitudinal axis is called roll and is controlled by the outboard movable portions of each wing: the **ailerons.** The term "aileron" is the French word for "little wing." Ailerons are located on the trailing (rear) edge of each wing near the outer tips. When deflected up or down, they in effect change the wing's camber (curvature) and its angle of attack. This changes the wing's lift and drag characteristics.
- Their primary use is to **bank (roll)** the airplane around its longitudinal axis. The banking of the wings results in the airplane turning in the direction of the bank, i.e., toward the direction of the low wing.
- The ailerons are interconnected in the control system to operate simultaneously in opposite directions of each other. As the aileron on one wing is deflected downward, the aileron on the opposite wing is deflected upward.
- The ailerons are controlled by turning the control yoke.

6.4 Secondary effect of aileron actuation:

The ailerons primarily control bank. However because the air underneath a wing is denser than that above it, the lowering aileron causes more drag on its side than the rising aileron. Using ailerons causes a small amount of yaw to occur. This is more pronounced for light aircraft with long wings, such as gliders. It is usually counteracted by the pilot with the rudder. Another most import consideration is that the **stall speed of the aircraft increases** with the angle of roll. Large angles of bank at slow speed may very well result in a stall and spin.

Vertical (yaw) axis -- an imaginary line extending vertically through the intersection of the lateral and longitudinal axes

- Rotation about the vertical axis is called yaw and is controlled by the rudder. This rotation is referred to as directional control or directional stability.
- The rotation is similar to a weather vane, in which the post holding the vane is the vertical axis but the rotation is directional.

6.5 Rudder:

The rudder is attached to the vertical stabilizer. Controlled by the rudder pedals, the rudder is used by the pilot to control the direction (left or right) of yaw about the airplane's vertical axis for minor adjustments. It is NOT used to make the airplane turn, as is often erroneously believed. Banking the airplane makes it turn.

When the foot pressure on the left rudder pedal moves the rudder to the left, causing the nose of the airplane to move to the left.

When the foot pressure on the right rudder pedal moves the rudder to the right, causing the nose of the airplane to move to the right.

6.6 Secondary effect of rudder Actuation:

Using the rudder causes one wing to move forward faster than the other. Increased speed means increased lift, and hence rudder use causes a small roll effect. For this reason ailerons and rudder are generally used together on light aircraft.

6.7 Stabilizers :

An **aircraft stabilizer** may provide longitudinal (or pitch) stability, or directional (or yaw) stability. A longitudinal stabilizer is a surface that provides forces that tend to keep an aircraft flying level and with unchanging "pitch" angles relative to the airstream; the nose of aircraft is prevented from pitching up or down. A directional stabilizer tends to keep the aircraft flying straight ahead with unchanging direction relative to the airstream (yaw stabilization). Static vertical stabilizers are small wing surfaces placed behind the center of mass of an aircraft, either as part of the tail empennage or outboard on aft-swept wings. A static horizontal stabilizer may be placed either behind the center of mass, as a tailplane, or forward of it as a canard foreplane.

Stabilizers can be fixed structures on which movable control surfaces are mounted, they can be movable for trimming pitch or yaw, or they can be operated as a fully movable control surface. Some types of aircraft include electronically controlled surfaces that may located anywhere needed and may serve as active stabilizers or motion dampers.

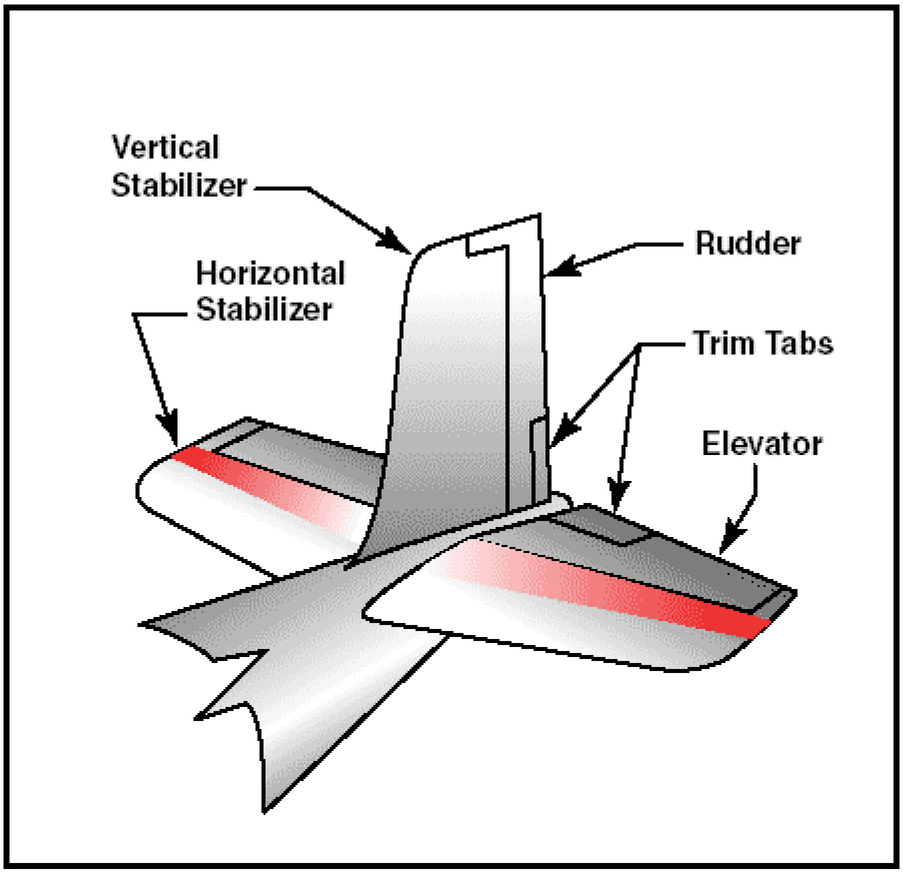


Fig 6.3 Control Surfaces

7. ANALYSIS OF WING

For the analysis of wing we used simulation software developed by NASA.

With this software one can investigate how an aircraft wing produces lift by changing the values of different factors that affect lift. FoilSim II is an early version of the FoilSim family of interactive simulations. The different versions of FoilSim require different levels of knowledge of aerodynamics, experience with the package, and familiarty with computer technology.

FoilSim II Version 1.5a

This is the beta 1.5a version of the FoilSim II program. You are encouraged to use the new FoilSim III simulation program that has all of the features of FoilSim II plus a calculation of the drag of the wing design. FoilSim II is no longer being supported by the NASA Glenn Educational Programs Office.

FoilSim II

With this software you can investigate how an aircraft wing produces lift by changing the values of different factors that affect lift.

FoilSim II is an early version of the FoilSim family of interactive simulations. The different versions of FoilSim require different levels of knowledge of aerodynamics, experience with the package, and familiarty with computer technology. The most recent (July, 2010) version of FoilSim is FoilSim III . This web page contains the on-line student version of FoilSim II. It includes an on-line user's manual which describes the various options available in the program and includes hyperlinks to pages in the Beginner's Guide to Aerodynamics describing the math and science of airfoils.

7.1 Elementary Version – FoilSimE:

There is a special version of FoilSim for elementary students who are just beginning to learn about wings and airfoils. This version only lets you change the speed, altitude, angle, camber, thickness, and area of the wing. Your only output is the lift in English units.

7.2 Undergraduate Version – FoilSimU:

There are special versions of FoilSim for undergraduate students who are studying computational modeling of airfoil problems. These versions let you change some of the assumptions in the analysis and have additional graphics to view the details of the analysis. There are on-line and off-line applet versions of the program and an off-line application version. With the application version, you can save your results to a file for printing. To run the application version, you must have Java installed on your computer.

7.3 GENERAL INSTRUCTIONS

This program is designed to be interactive, so you have to work with the program. There are a variety of choices which you must make regarding the analysis and the display of results by using a choice box. A choice box has a descriptive word displayed and an arrow at the right of the box. To make a choice, click on the arrow, hold down and drag to make your selection. The current values of the design variables are presented to you in boxes. By convention, a white box with black numbers is an input box and you can change the value of the number. A black box with yellow numbers is an output box and the value is computed by the program. To change the value in an input box, select the box by moving the cursor into the box and clicking the mouse, then backspace over the old number, enter a new *number*, then hit the Enter key on your keyboard.

Using this simulation we found out results by giving various inputs. We had collected the results. The graphs and results are collected and shown here. Using this software we can get analysis of wing by varying different input parameters and the results for our input values according to design of our wing are shown here.

7.4 <u>Lift force acting on wing (Earth average day):</u>

Wing Span : 4.57m

Chord Length : 1.4m

No. of Wings: 2

%chord thickness:11%

%camber: 5.71%

Angle of Attack:15 degrees

Lift Force: 2700N

Density of air: 1.224kg/m^3

Aspect Ratio:3.264

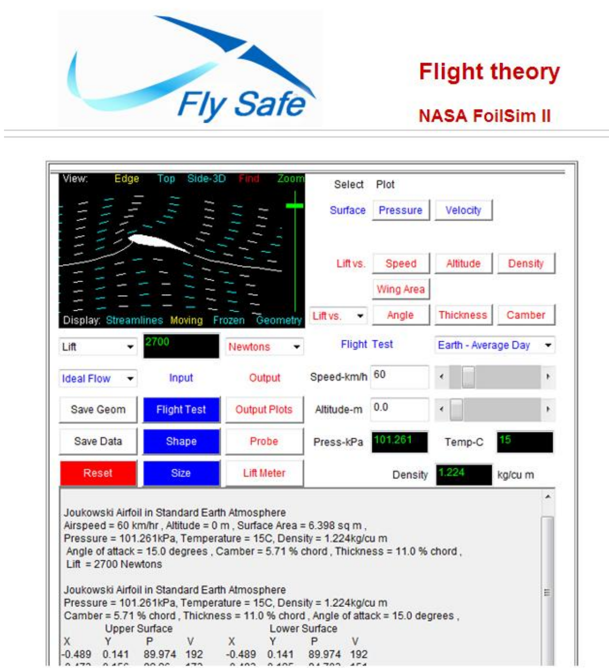


Fig 7.1 Wing Geometry

7.5 <u>Wing Profile:</u>

The co-ordinates of our wing profile is as follows:

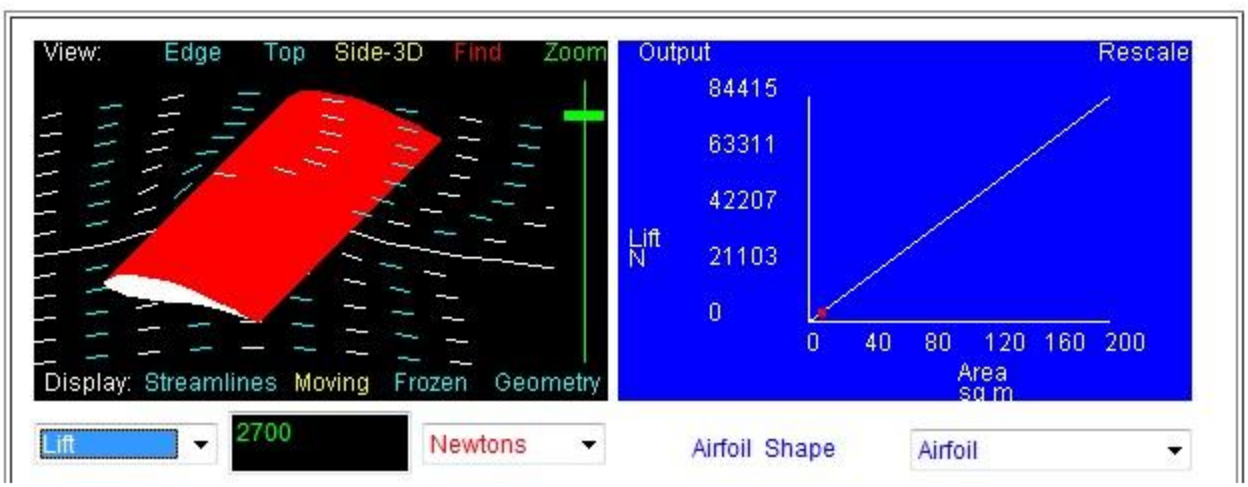
Camber = 5.71 % chord , Thickness = 11.0 % chord , Angle of attack = 15.0 degrees ,

Upper Surface				Lower Surface			
X	Y	P	V	X	Y	P	V
-0.489	0.141	89.974	192	-0.489	0.141	89.974	192
-0.473	0.156	92.26	173	-0.493	0.125	94.703	151
-0.445	0.168	94.469	153	-0.484	0.108	101.016	66
-0.405	0.177	95.864	140	-0.46	0.091	102.429	16
-0.357	0.181	96.797	129	-0.423	0.075	102.498	8
-0.3	0.179	97.487	121	-0.373	0.06	102.362	21
-0.236	0.172	98.044	114	-0.309	0.046	102.233	29
-0.166	0.16	98.524	108	-0.234	0.033	102.142	33
-0.093	0.141	98.954	102	-0.149	0.021	102.083	35
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0.057	0.088	99.716	90	0.038	-0.0070	102.023	38
0.132	0.056	100.055	85	0.134	-0.024	102.004	39
0.204	0.022	100.366	79	0.226	-0.044	101.984	39
0.272	-0.012	100.647	74	0.308	-0.066	101.957	40
0.333	-0.046	100.899	69	0.377	-0.087	101.921	42
0.387	-0.076	101.121	64	0.43	-0.106	101.871	43
0.431	-0.1	101.312	59	0.465	-0.121	101.804	45
0.462	-0.118	101.474	55	0.481	-0.128	101.717	48
0.48	-0.127	101.608	51	0.48	-0.127	101.608	51

Fig 7.2 Wing Profile Co-ordinates

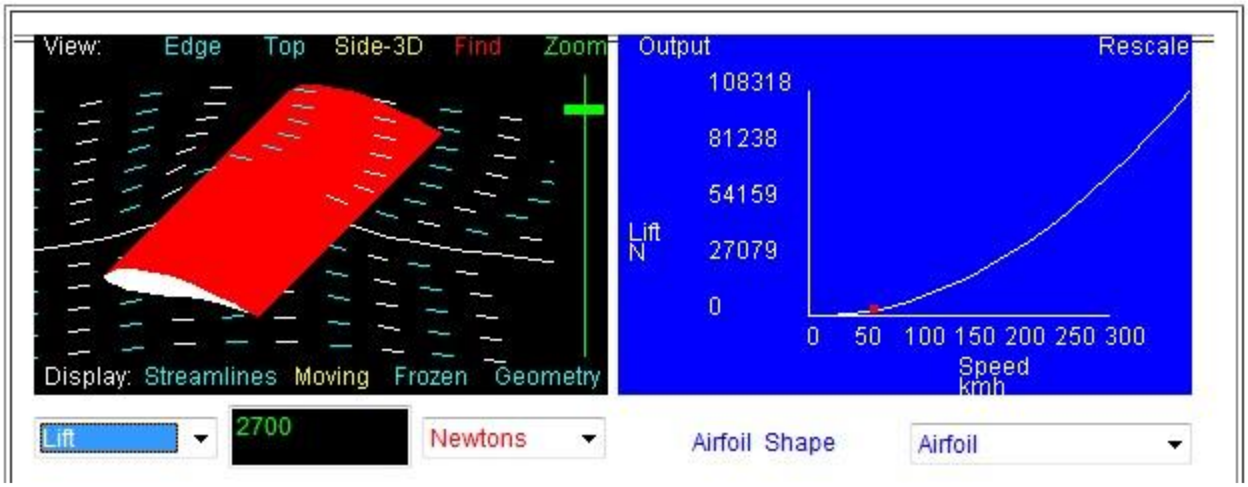
7.6 <u>Graphs:</u>

Graph 7.1: Lift vs Wing Area



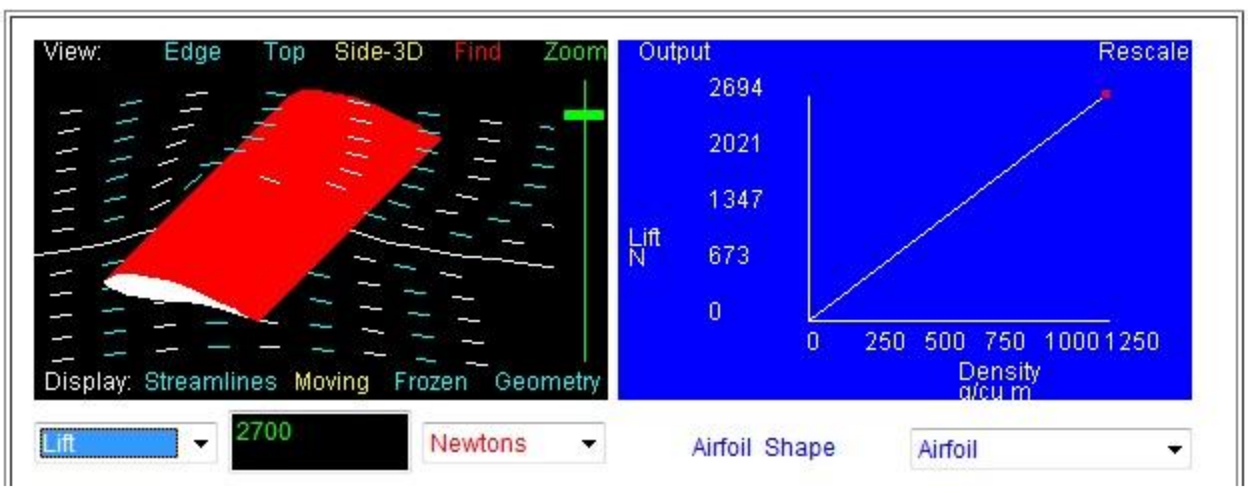
Lift force is directly proportional to the wing area. Lift force linearly varies with the area.

Graph 7.2: Lift vs Speed:



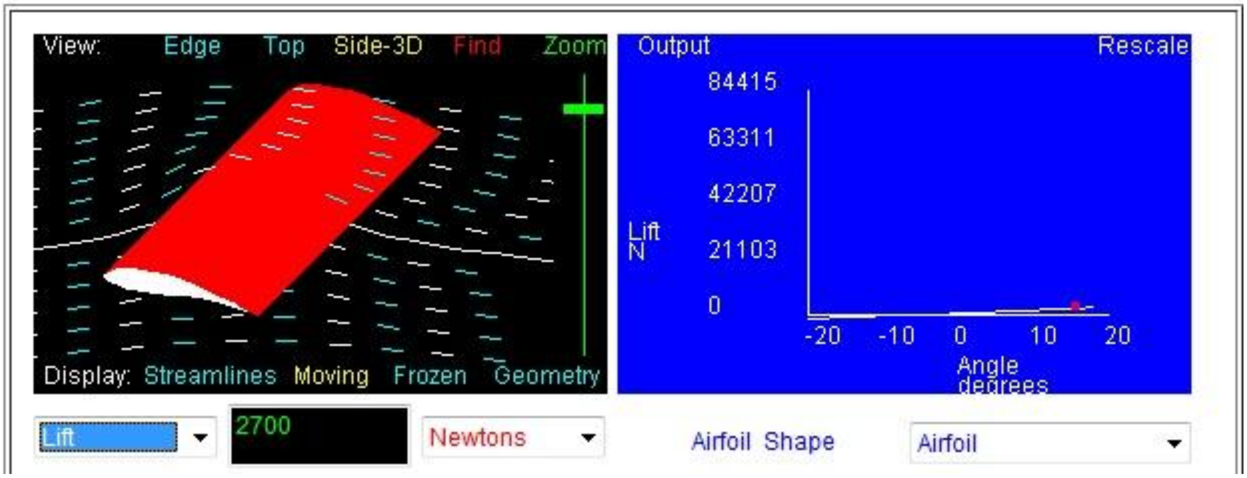
Lift force is directly proportional to velocity of the air flow. As the air flow speed increases on the wing surface the lift force increases and varies parabolically. We are able to achieve a sufficient lift force at an air velocity of 60kmph.

Graph 7.3: Lift vs Density:



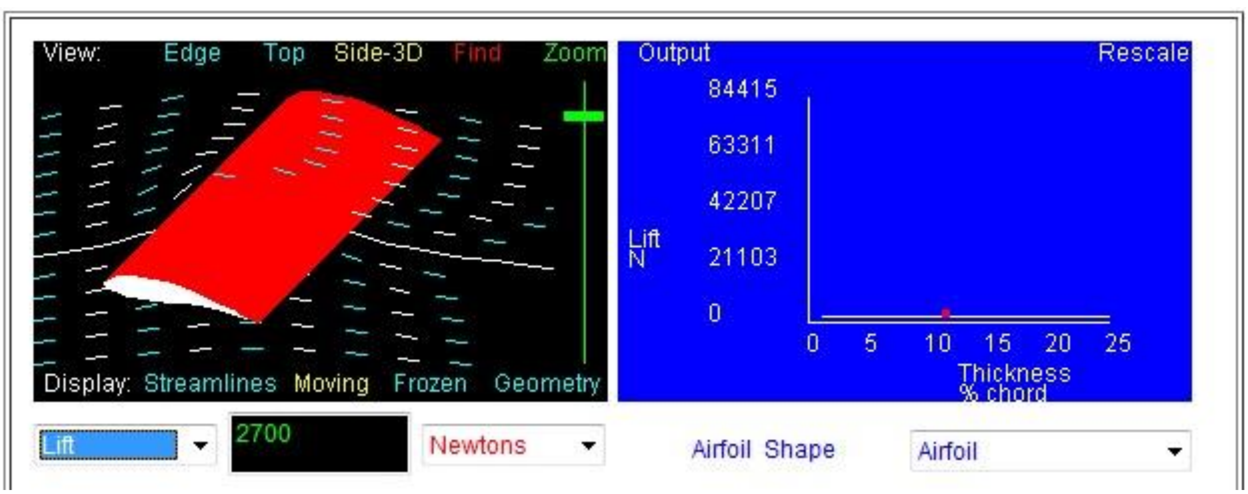
Lift force linearly varies with density of air. Density of air depends upon altitude. So, lift force is dependent on altitude.

Graph 7.4 Lift force vs Angle of attack:



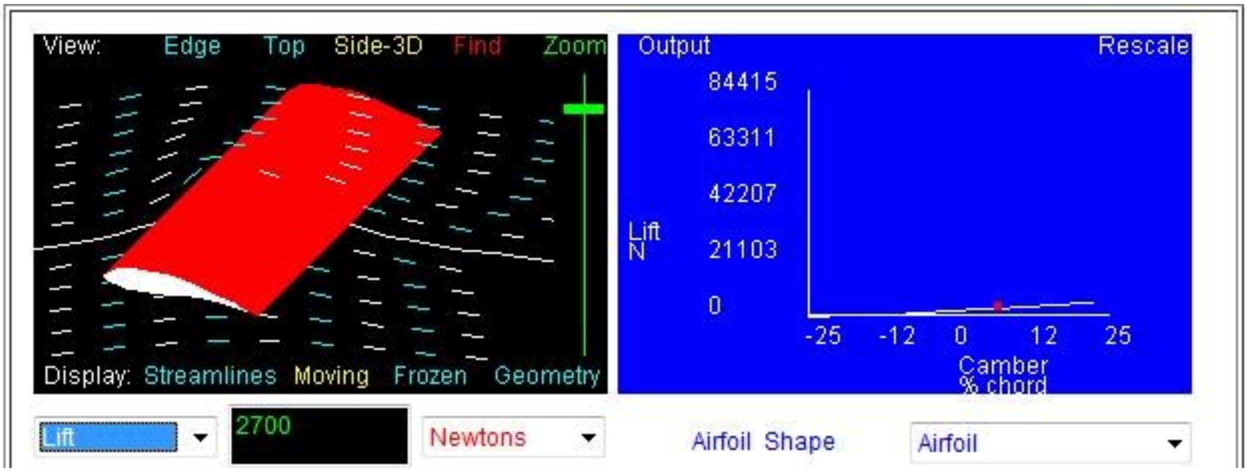
Lift force is dependent on the angle of attack as the angle of attack increases the lift force increase upto critical angle of attack of 16^0 and then stalling occurs.

Graph 7.5 Lift force vs % chord thickness



The variation of lift force due to % of chord thickness on the lift force is negligible.

Graph 7.6 Lift force vs % camber:



Lift force vary with the change in camber of the wing cross section as shown in the graph.

These are the different graphs indication of change in Lift force with all the above parameters.

8. OUR PROJECT DESIGNS

8.1 Wing Design:

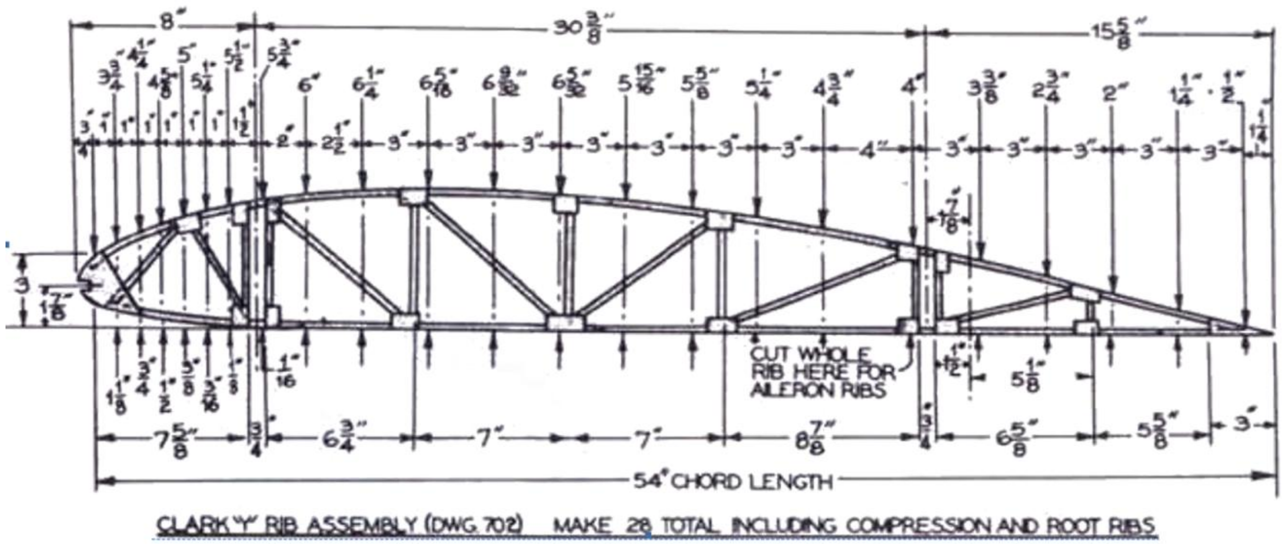


Fig 8.1 Cross section of the wing

Chord length : 54”

Total Wing Span: 30ft

Aspect Ratio Maintained: 3.264

Angle of Attack : 15 degrees on ground

8 degrees in air

Overall Lift force at 0 m Altitude is 5400 Newton’s

8.2 Fuselage Design:

In order to compensate for Weight balancing of the entire flight Fuselage of 13ft is Chosen for the optimum Design.

Overall Weight Acting at the front of passenger chamber is around 60kg.inorder to balance the moment we used a 13ft length of fuselage so that it will balance in still air.

Fuselage Length: 13ft

Fuselage truss material : 22mm Aluminium Pipes

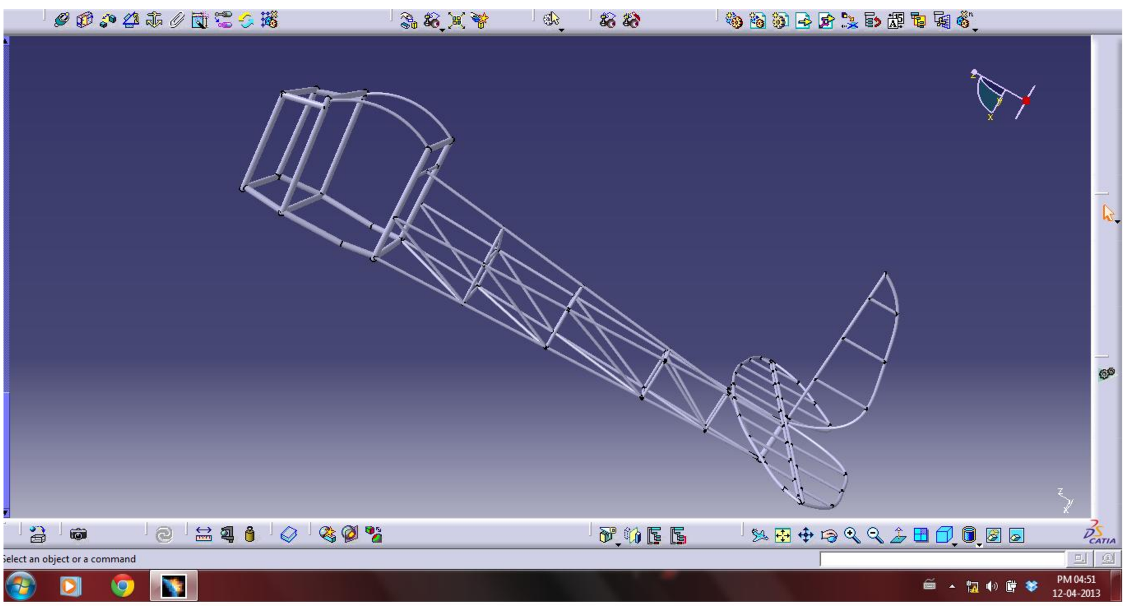


Fig 8.2 Fuselage of the designed Air craft.

Sketch of fuselage with overall length of 13ft

22mm Aluminium pipes are chosen into consideration after Analysis of the fuselage frame model in ANSYS

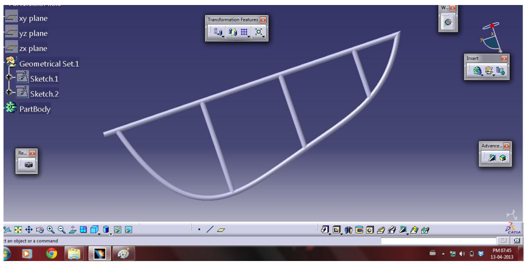
There is a Deflection of about 0.5 mm with a load of 10KN.

Hence we went with this design for fuselage which is light weight and also withstand our purpose.

8.3 Rudder & Vertical Stabilizer Design:

Rudder:

The rudder design is as follows:



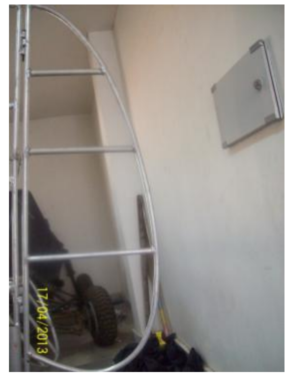


Fig 8.3 These are our Catia and made structure of our rudder.

Vertical Stabilizer:

The vertical stabilizer design is as follows:

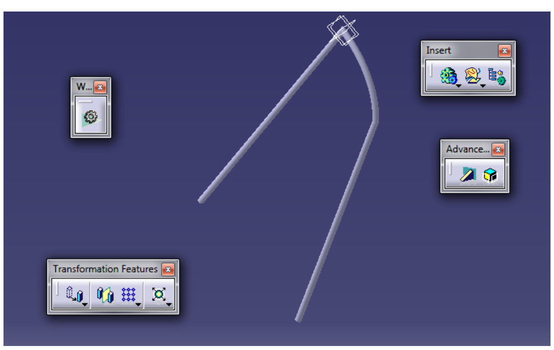


Fig 8.4: These are our Catia and designed structure of our vertical stabilizer.

8.4 <u>Elevator and Horizontal Stabilizer:</u>

Elevator:

Elevator is the main part to lift the aircraft

These designs are chosen in appropriate to the size of the fuselage

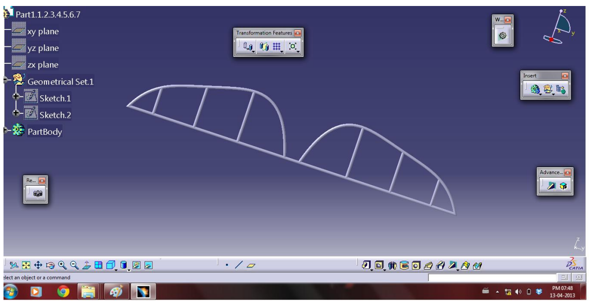


Fig 8.5: These are our Catia and designed structure of our Elevator.

Horizontal Stabilizer:

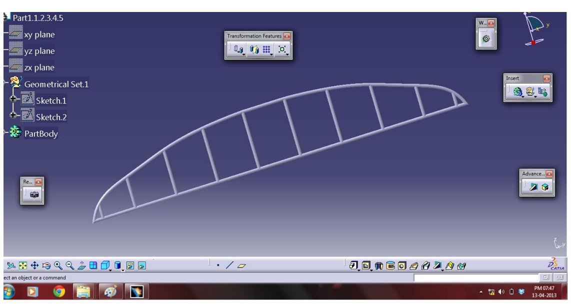


Fig 8.6: These are our Catia and designed structure of our Horizontal Stabilizer.

9. DESIGN

9.1 CATIA:

CATIA (Computer Aided Three-Dimensional Interactive Application) is a multiplatform CAD/CAE/CAM commercial software suite developed by French company Dassault Systems.

The software was created in the late 1970's to develop Dassault's Mirage fighter jet, but was subsequently adopted in the Aerospace, Automotive shipbuilding, and other industries. The software was also used by architect Frank Gehry in his building of the Guggnheim Museum Bilbao and Wait Disney Concert Hall.

Fig 9.1 Catia Package

9.2 HISTORY OF CATIA :

CATIA started as an in-house development by French aircraft manufacturer Avions Marcel Dassault, at that time customer of the CADAM CAD software
The software name was initially CATI (Conception Assistee Tridimensionelle Interactive- French for Interactive Aided Three Dimensional Design), but was renamed CATIA in1981.

In 1984, the Boeing company chose CATIA as its main 3-D CAD tool, making it the largest customer.

In 1988, with version 3, CATIA was ported from the mainframe to the UNIX platform.
In 1900, General Dynamics/Electric Boat Corp chose CATIA as its main 3D CAD tool, to design the United States Navy Virginia Class Nuclear Submarine.
In 1992 CADCAM was purchased from IBM and the next year CATIA CADAM v4 was published. Subsequently in 1996 CATIA v4 was ported from one to four Unix operating systems, including IBM AIX, Silicon Graphics IRIX, Sun Microsystems SunOS and Hewlett Packard HP-UX.
In 1998, an entirely rewritten version of CATIA v5 was released, with support for both UNIX, Windows NT and Windows XP since 2001.

9.3 CHASSIS DESIGN:

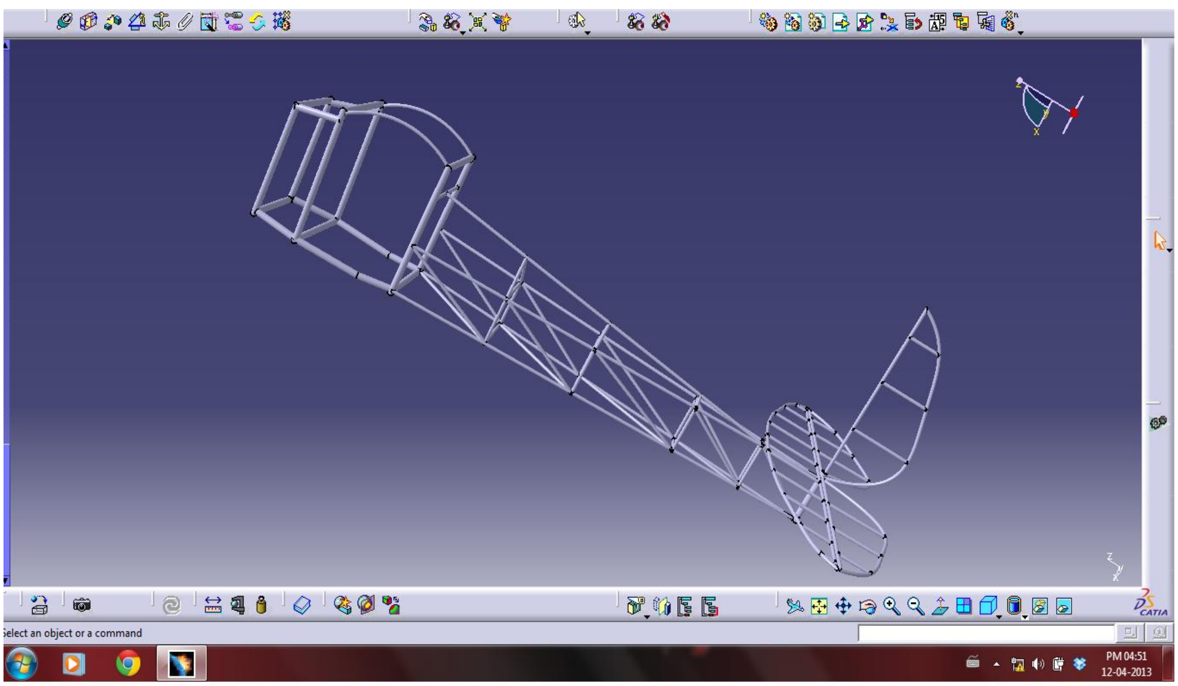


Fig 9.2 Main chassis of our project

9.4 BACK TRUSS :

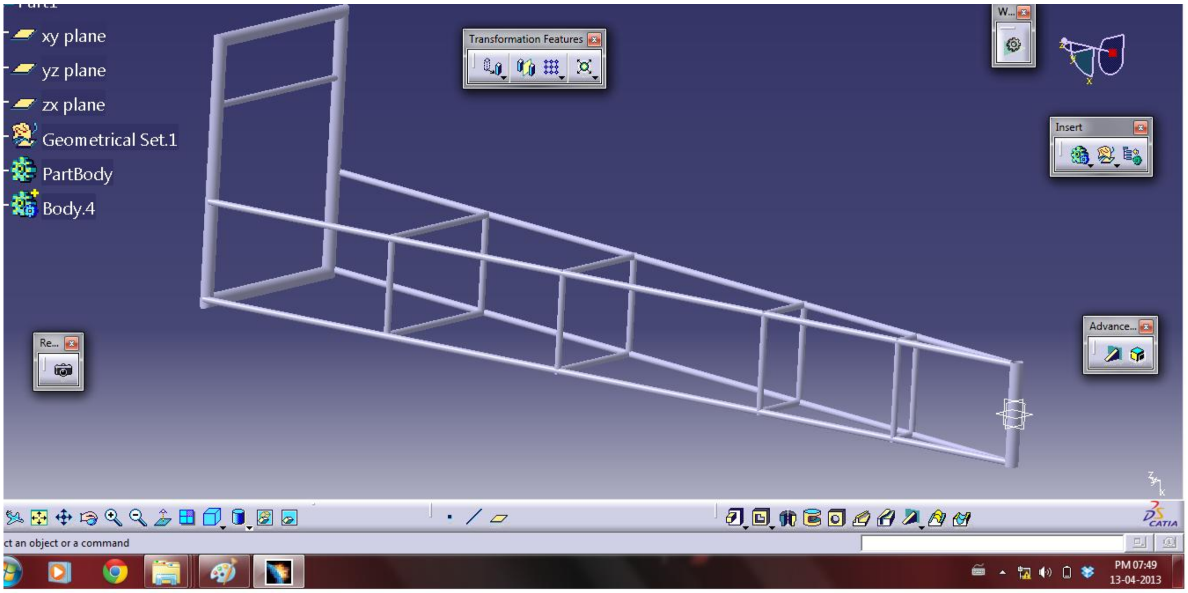


Fig 9.3 Back skeleton

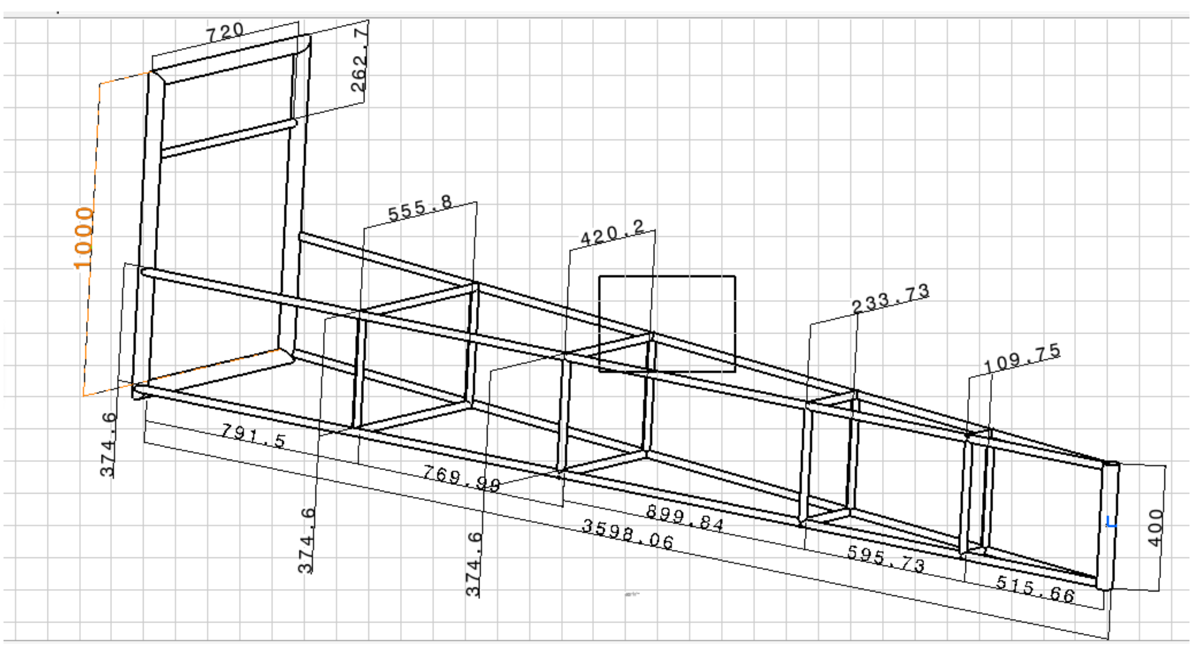


Fig 9.4 Back skeleton draft

9.5 WING DESIGN:

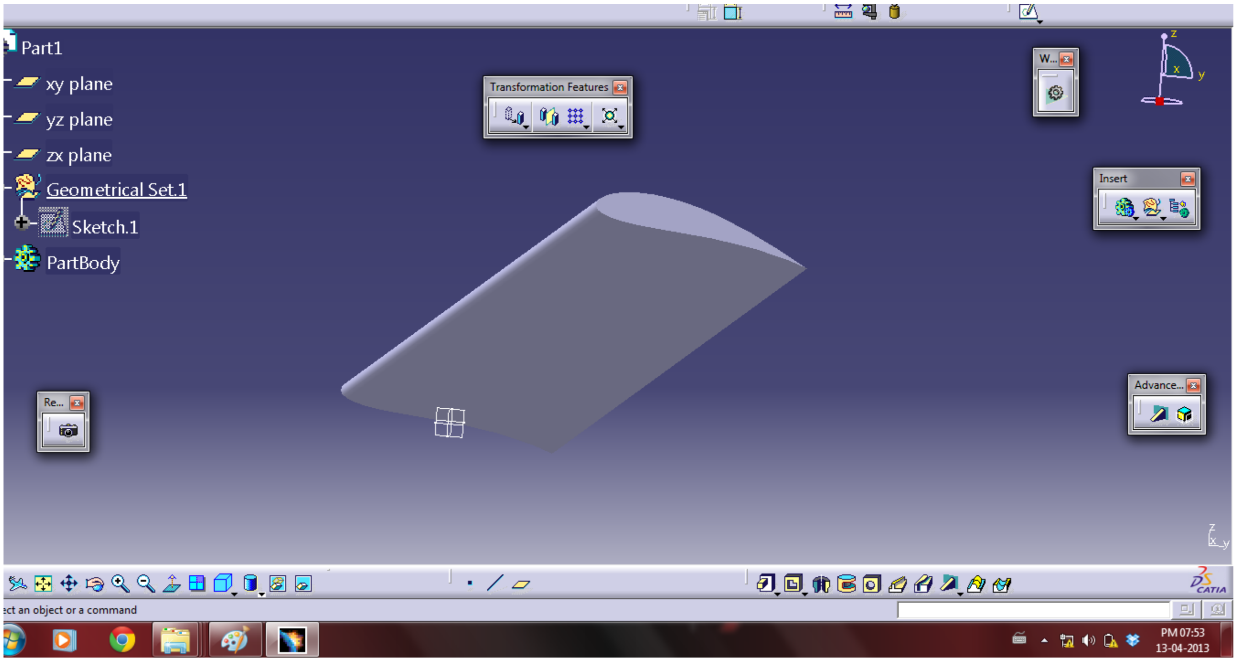


Fig 9.5 Wing design full length

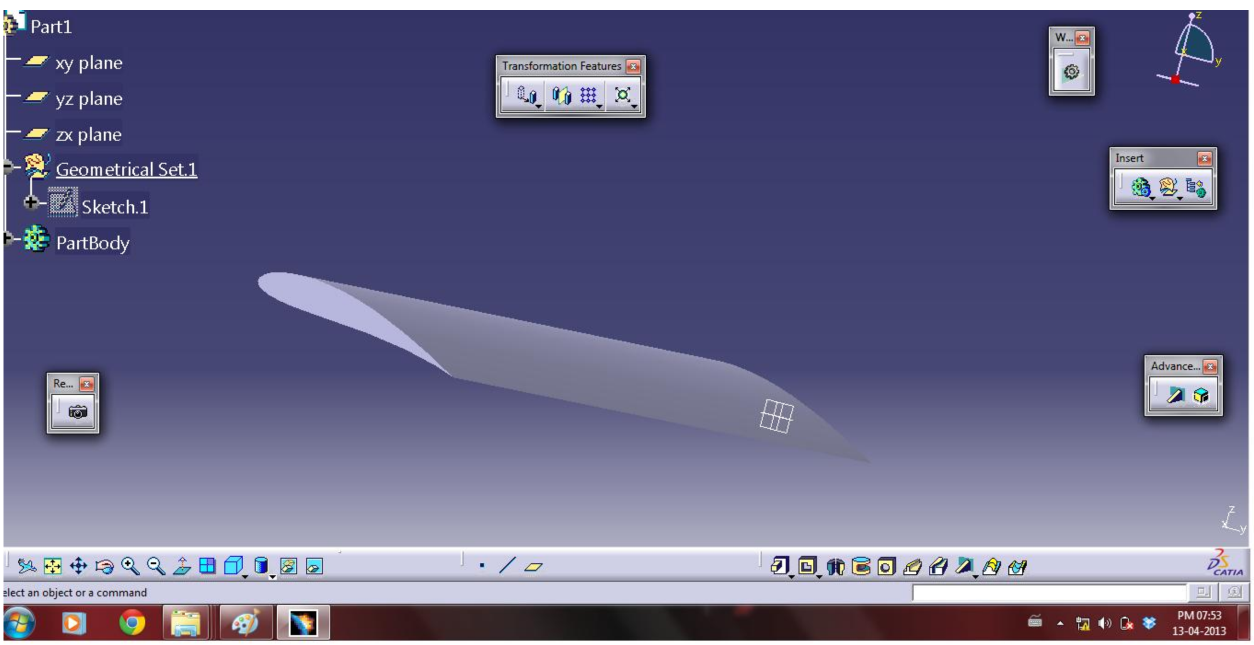


Fig 9.6 wing design full length

9.6 ELEVATOR:

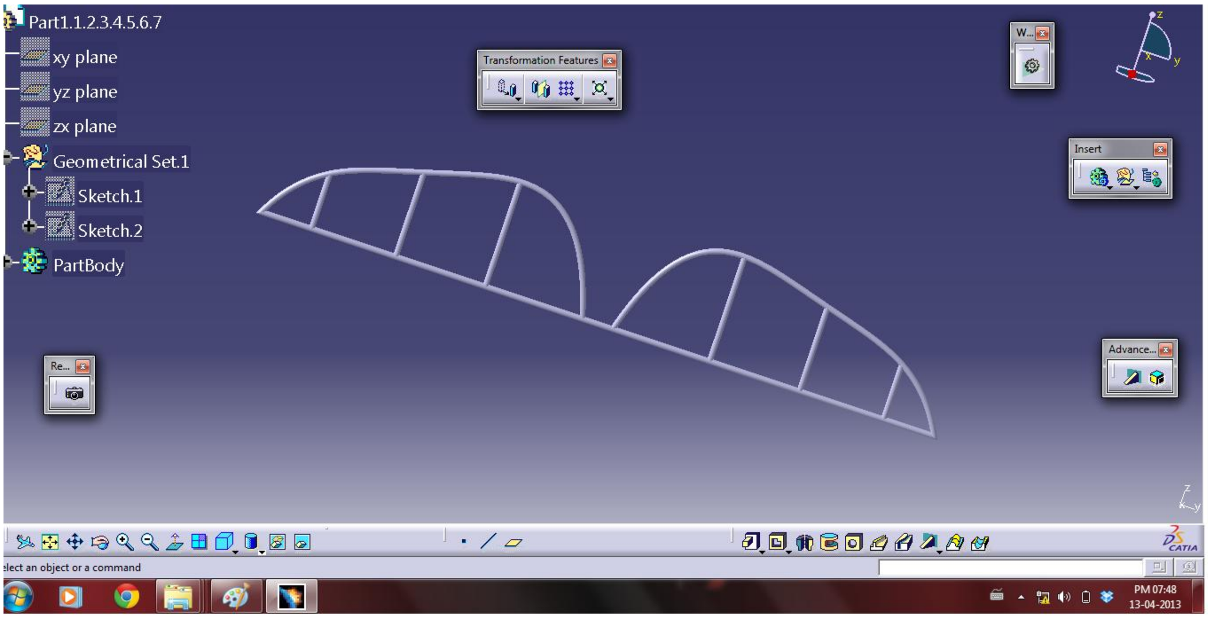


Fig 9.7 Elevator design

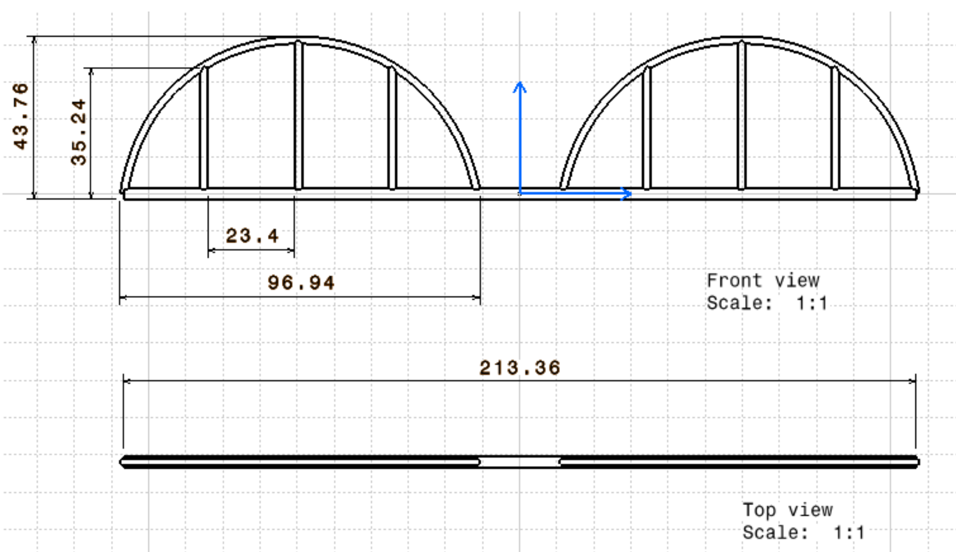


Fig 9.8 Elevator draft

9.7 <u>HORIZONTAL STABILIZER:</u>

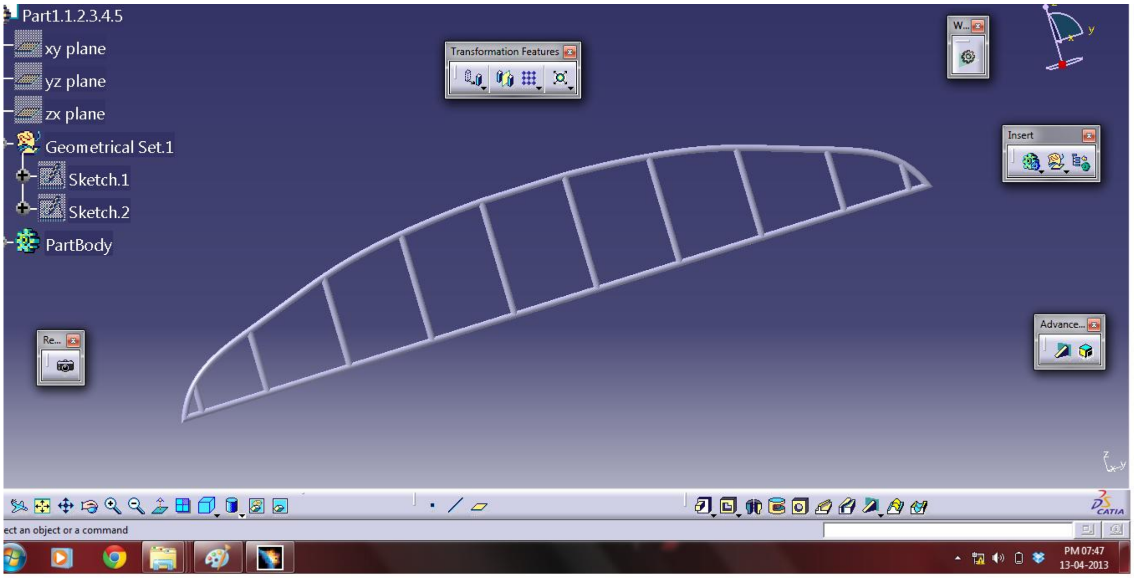


Fig 9.9 Horizontal stabilizer design

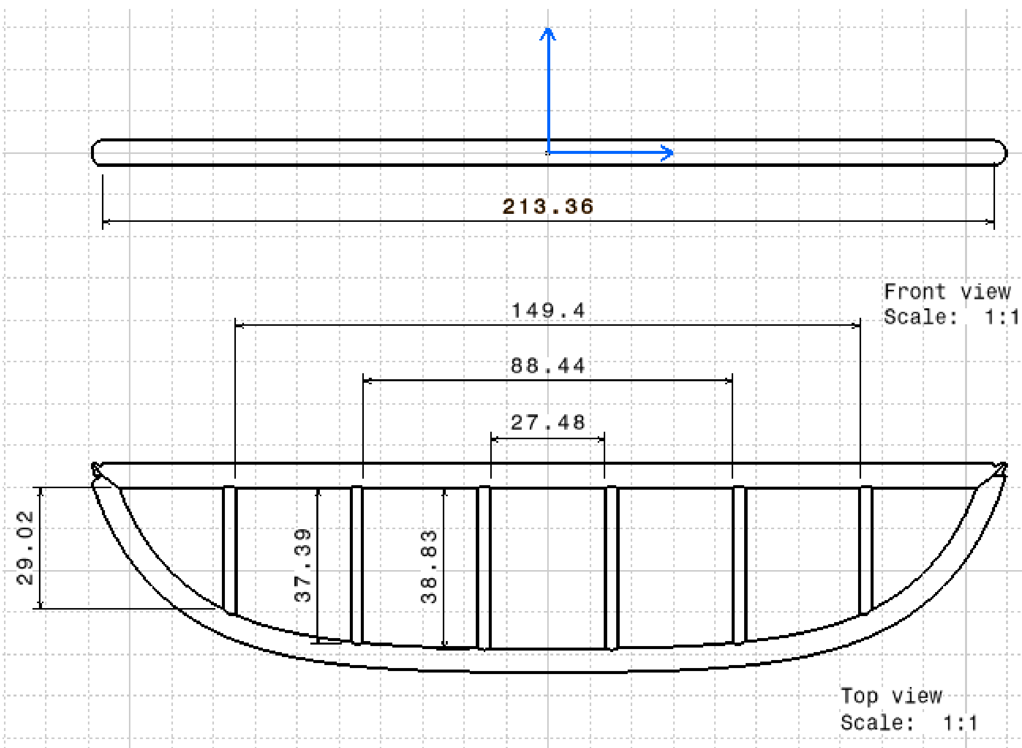


Fig 9.10 Horizontal stabilizer draft

9.8 RUDDER:

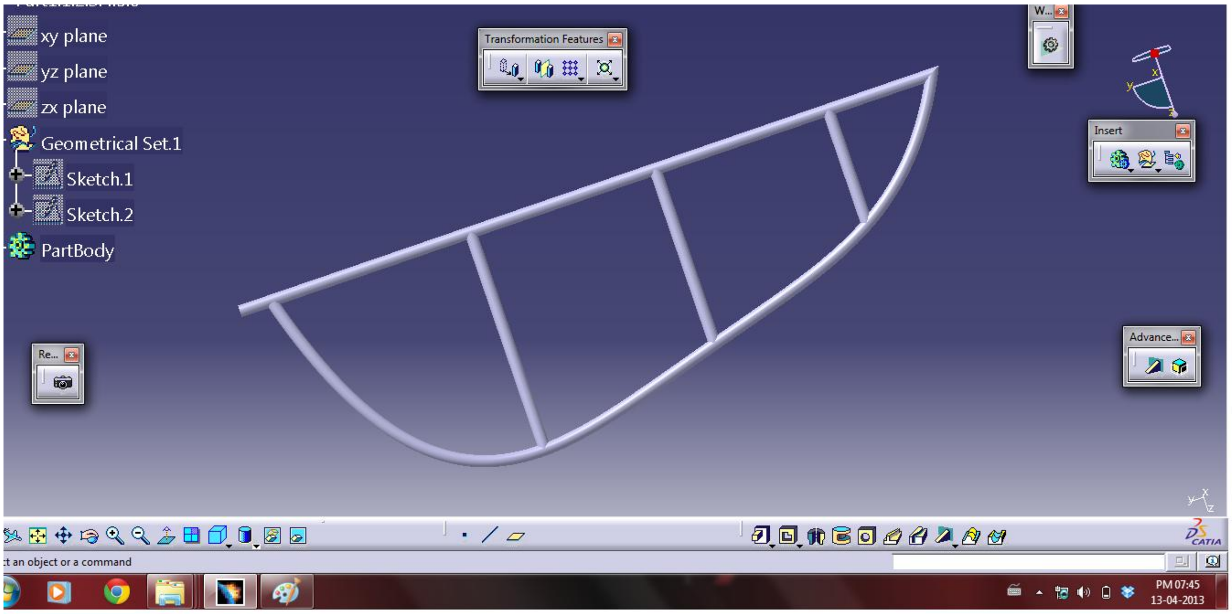


Fig 9.11: Rudder design

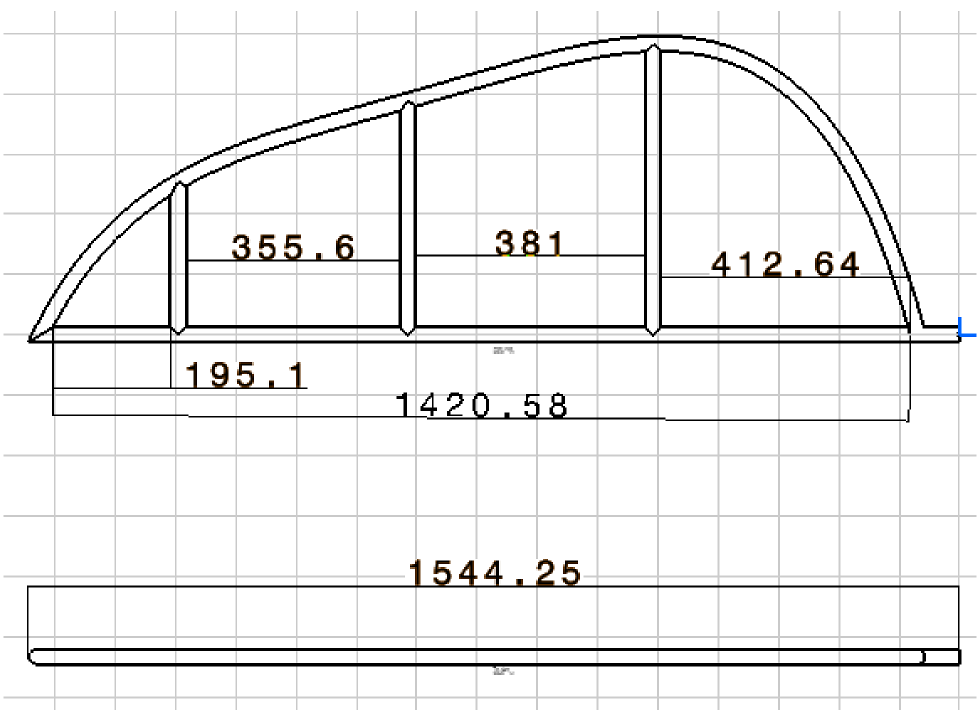


Fig 9.12: Rudder draft

10. Results & Conclusion

Ansys Results:

S.No		With 10KN impact load	With 20KN impact load
1.	Deflection of fuselage truss with impact load.	0.5mm	4.3mm
2.	Deflection of springs with impact load.	3.53cm	--

Wing Analysis Results (on a single wing):

S.No.	Chord Length	Wing Span	% of Chord Thickness	% of Camber	Angle Of Attack	Lift Force
1.	1.4m	4.57m	11	5.71	15^0	2700N

From this result we have designed the required fuselage frame of the Baby Ace.

Conclusion:

Aero design series aims to give a real world engineering design opportunity to universities across the world. The engineering design goal is to take off and land an aircraft while carrying as much weight as possible. This engineering goal can only be met by applying the principles aerodynamics, material mechanics, physics, and other engineering principles.

There are also challenges with design process:

Time management, budget, and team dynamics all create unforeseen obstacles. The design process for this competition starts in the early fall and continues through competition in April. During the design process there are many problems that arise. In order to be successful in this competition, the design must be adapted and enhanced along the way.

Our Team aims to design and build an aircraft that maximizes lift at low airspeeds while maintaining a robust, stable, lightweight, modular, and easy to machine design. With a combination of experience, new research, testing, and critical assessment, our design team is meeting that objective.

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