Wing Design
Home Educators Pack
July 2026

ROYAL AIR FORCE museum

Introduction

This resource pack is designed for students working at an Upper KS2 or KS3 level, it can be used at home or during a visit to The RAF Museum.

These resources are designed to encourage cross-curricular learning focusing on the key skills of STEM, communication, design,critical thinking and research.

It will introduce some basic concepts associated with flight

- Examine aerodynamics
- Provide an understanding of the history of wing design
- Assess Wing Design purpose and success
- Enable students to design their own aircraft wings.

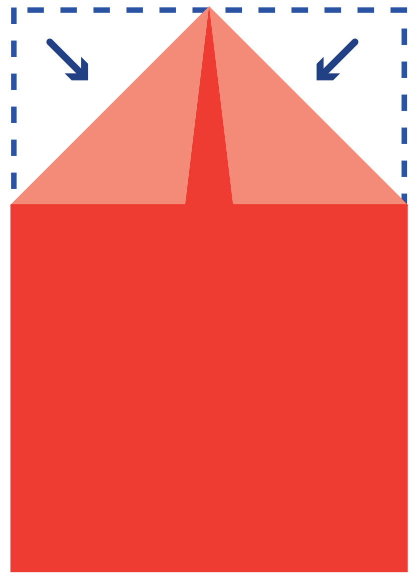
Principles of flight activity

Let’s make a paper plane
You will need an A4 sheet of paper.

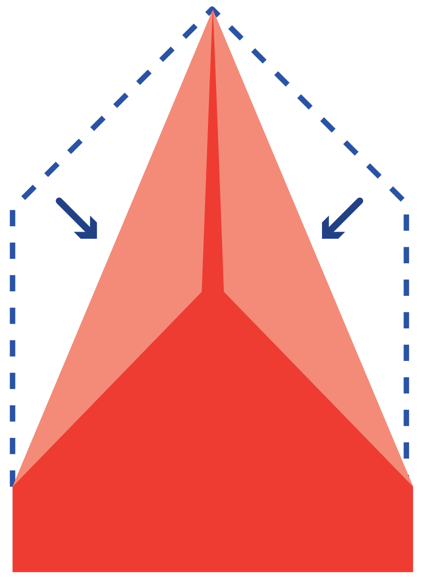
Once you have flown your plane, think about
- Why do these designs behave differently to a scrunched-up piece of paper?
- How do your paper planes compare with the shapes of real planes you’ve seen?

Follow these steps

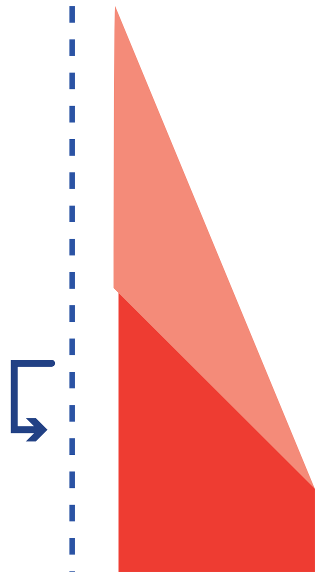
Take the A4 sheet of paper. Fold it in half, as shown, then unfold it



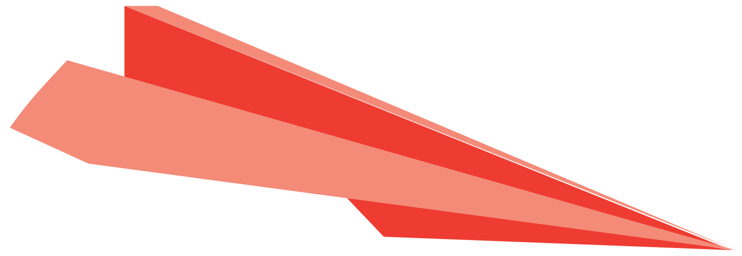
Fold the two top corners in to make a point



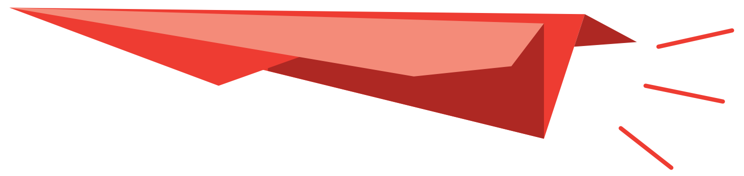
Fold the edges in again so they meet in the middle from the tip



Fold the plane in half again



Now fold the diagonal edge down to meet the straight edge on each side, making the wings



Test out your paper plane!

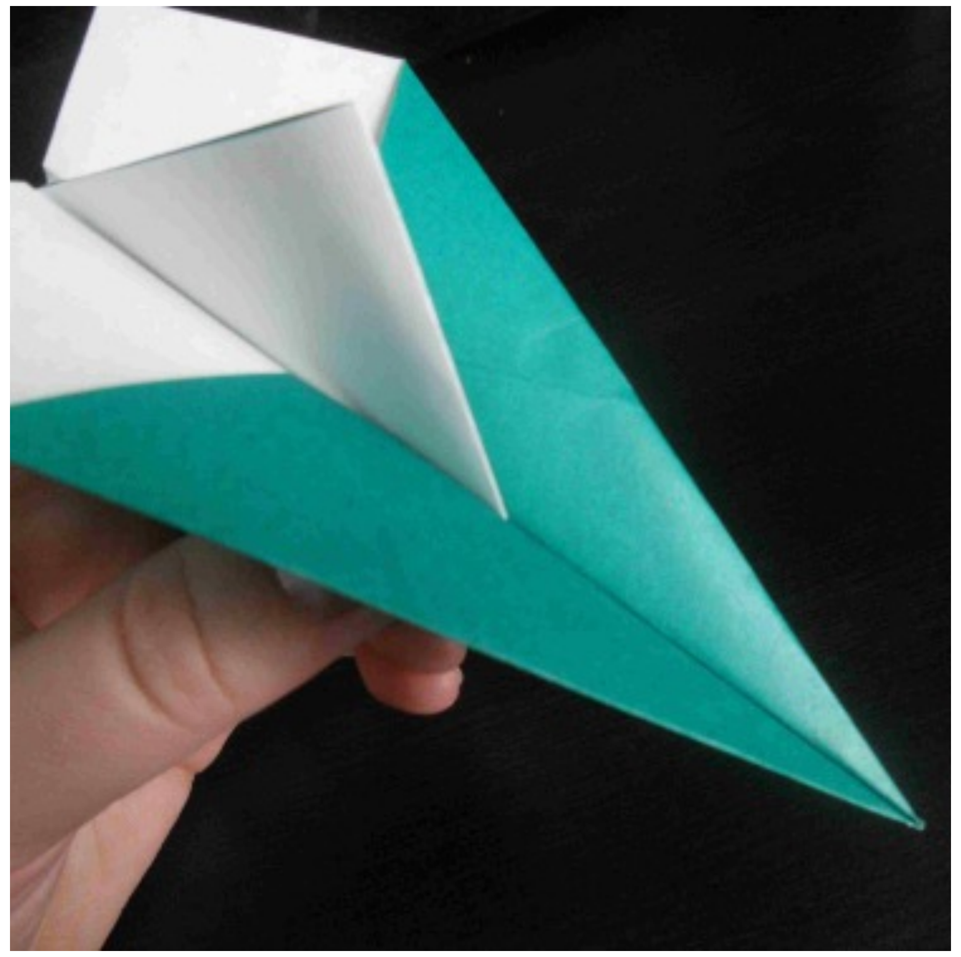
Principles of flight

A paper aeroplane falls to the ground more slowly than a scrunched-up piece of paper, that's because of the forces generated by and pressing on the paper.

Gravity pulls everything downwards. But as they move towards the ground the wings of an aircraft create higher air pressure underneath than on top. This creates a lift force that counteracts some of gravity's pull and makes them fall more slowly.

Moving through air also creates a kind of friction called air resistance, or drag which slows down anything moving through the air.

Real aircraft create lift in the same way as paper planes, but they have powerful engines that push them through the air creating continual lift.



Aerodynamics | Lift

- Lift is the force that directly opposes the weight of an aeroplane and holds the aeroplane in the air
- The wings generate most of the lift on a normal aeroplane
- Lift is a force produced by the motion of the aeroplane through the air. Because lift is a force, it has both a magnitude and a direction associated with it.
- Lift works roughly perpendicular to the wing.
- Lift occurs when the wings deflect a moving flow of air.
- For most aeroplanes, the wings generate lift through two different means: 1) impact lift and 2) lift through the Bernoulli Effect.

Impact Lift | The angle of attack

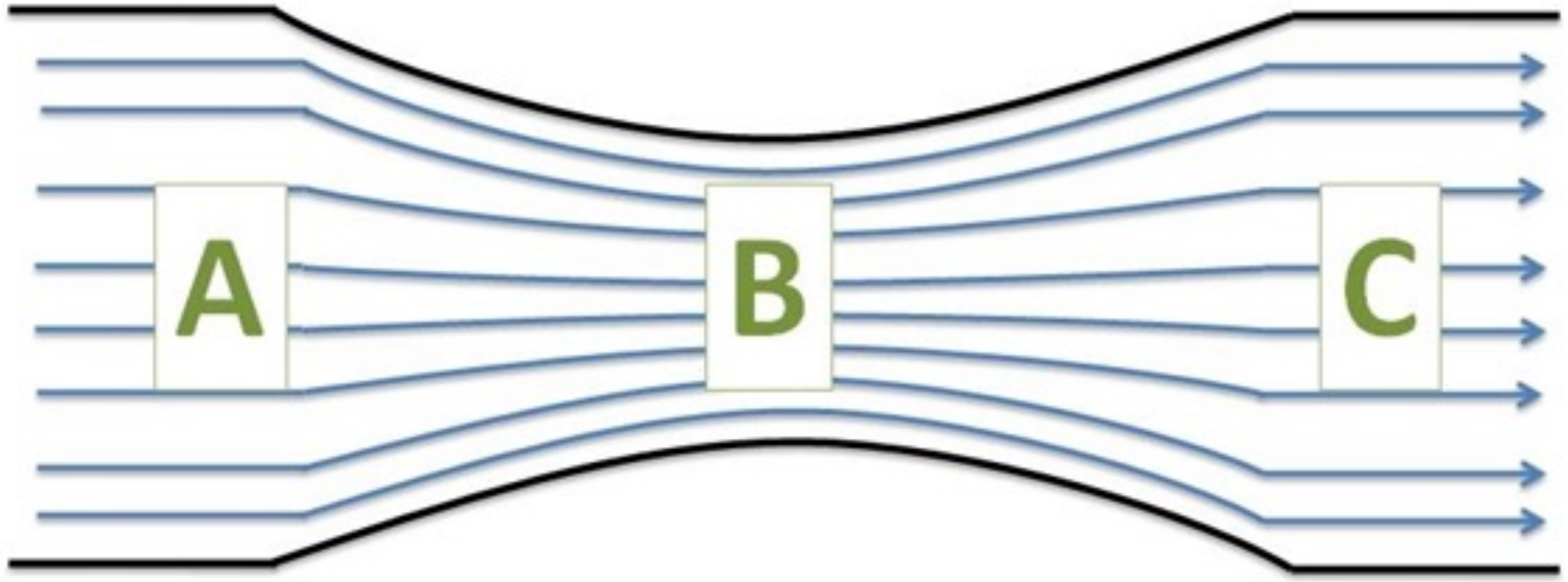
- Impact lift is the simplest to understand and is responsible for most lift generated by an aeroplane at low speeds
- As an aeroplane moves forward, its nose is pitched slightly upward into the oncoming airflow, forcing the wings to meet the air at an angle
- The angle an aeroplane wing makes with the oncoming air is called the angle of attack. The angle of attack can be changed by pitching (moving) the aeroplane nose up or down
- As the aeroplane wing strikes the air at an angle, the airflow is turned downwards
- Lift is generated in the opposite direction. As Newton's Third Law of Motion states; 'For every action there is an equal and opposite reaction'
- For an aircraft wing, both the upper and the lower surfaces contribute to deflecting airflow.

Lift through the Bernoulli Effect

- Bernoulli's Law states that fluids (such as air) exert less pressure at higher speeds than at lower speeds.
- Most aeroplanes have wing shapes (aerofoils) that force air to move over their top surfaces more quickly than their bottom surfaces.
- When a wing is designed in this way, air presses on the bottom of the wing harder than on the top. This difference in pressure results in lift that helps keep the airplane in the air.
- The Bernoulli Effect increases at higher airspeeds when the aeroplane is flying at a smaller angle of attack.
- When airspeed is low and the angle of attack is high, or in an aeroplane with air foils that are not curved properly, or that may be curved the wrong way (as is the case when an airplane flies upside down), there may be little or no lift generated by Bernoulli's Law..
- Lift is a mechanical force. It is generated by the contact of a solid body with a gas such as air. For lift to be generated, the solid body must be in contact with the air—no air, no lift.

The Bernoulli Effect

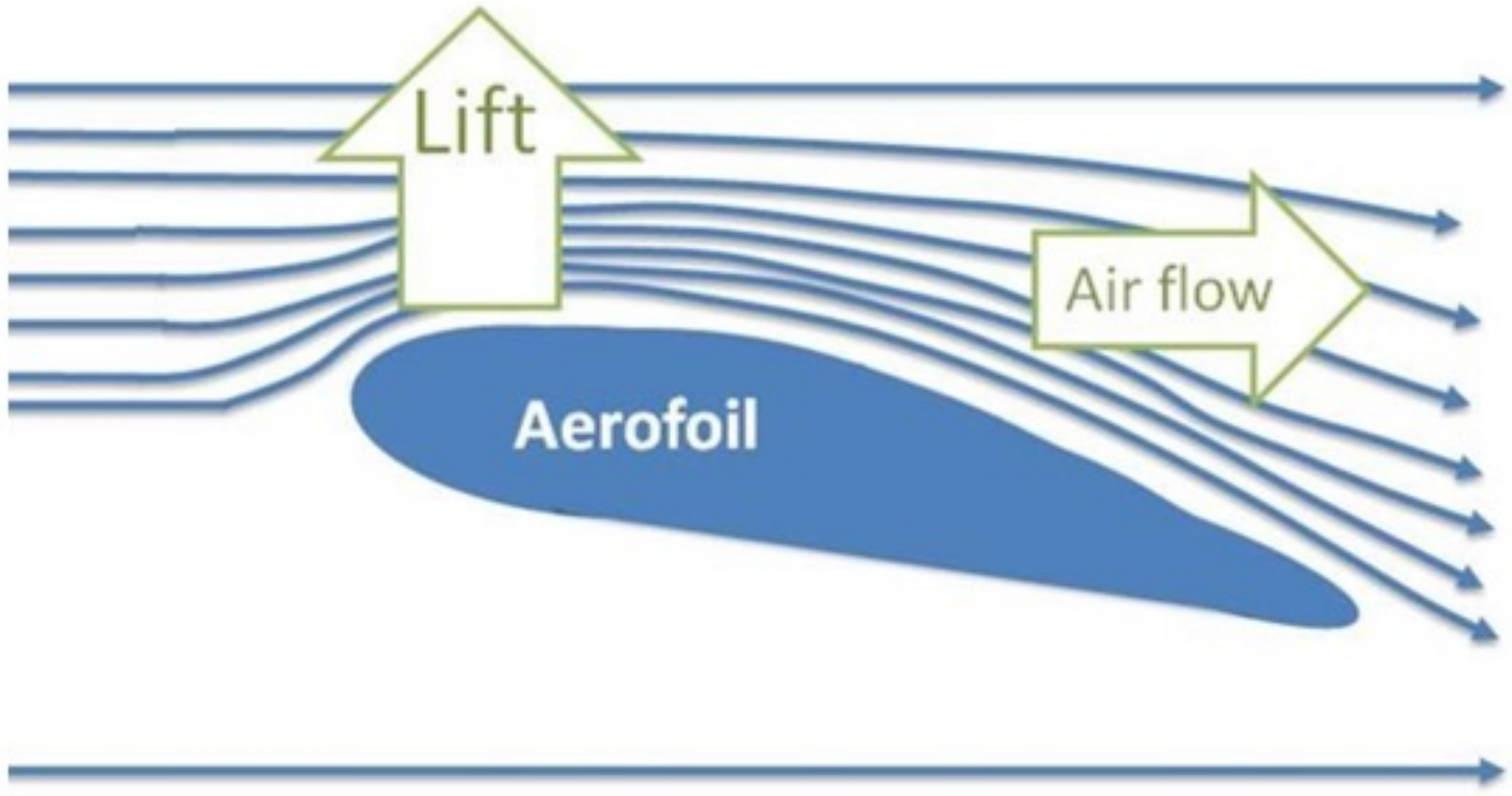
- The ‘Bernoulli Effect’ can be seen in a simple experiment where air is blown into a wind tunnel which has been narrowed in the middle (as shown in the diagram).
- Airspeed and air pressure are measured at A, B and C. As the tunnel narrows at B, the air must speed up to get through, and as the tunnel widens it slows down again. When we measure the pressure and speed at the three points A, B and C we find that at point B, where the air is moving fastest, the pressure drops.
- Aeroplane wings are designed to make use of this change.



The Importance of Wings

- A wing is a type of fin with a surface that produces aerodynamic force for flight or propulsion through the atmosphere or through a gaseous or other liquid fluid.
- As such wings have an aerofoil shape, a streamlined cross sectional shape producing lift.
- Aeroplane wings are designed to create a similar ‘narrow space’ (like point B in the diagram) but they create it in the air itself using the bulk of the atmosphere like the sides of a big wind tunnel.
- Think of all the air below the wing as the ‘floor’ of the wind tunnel, and the all the air pressing down above the wing as the ‘ceiling’ of the wind tunnel.

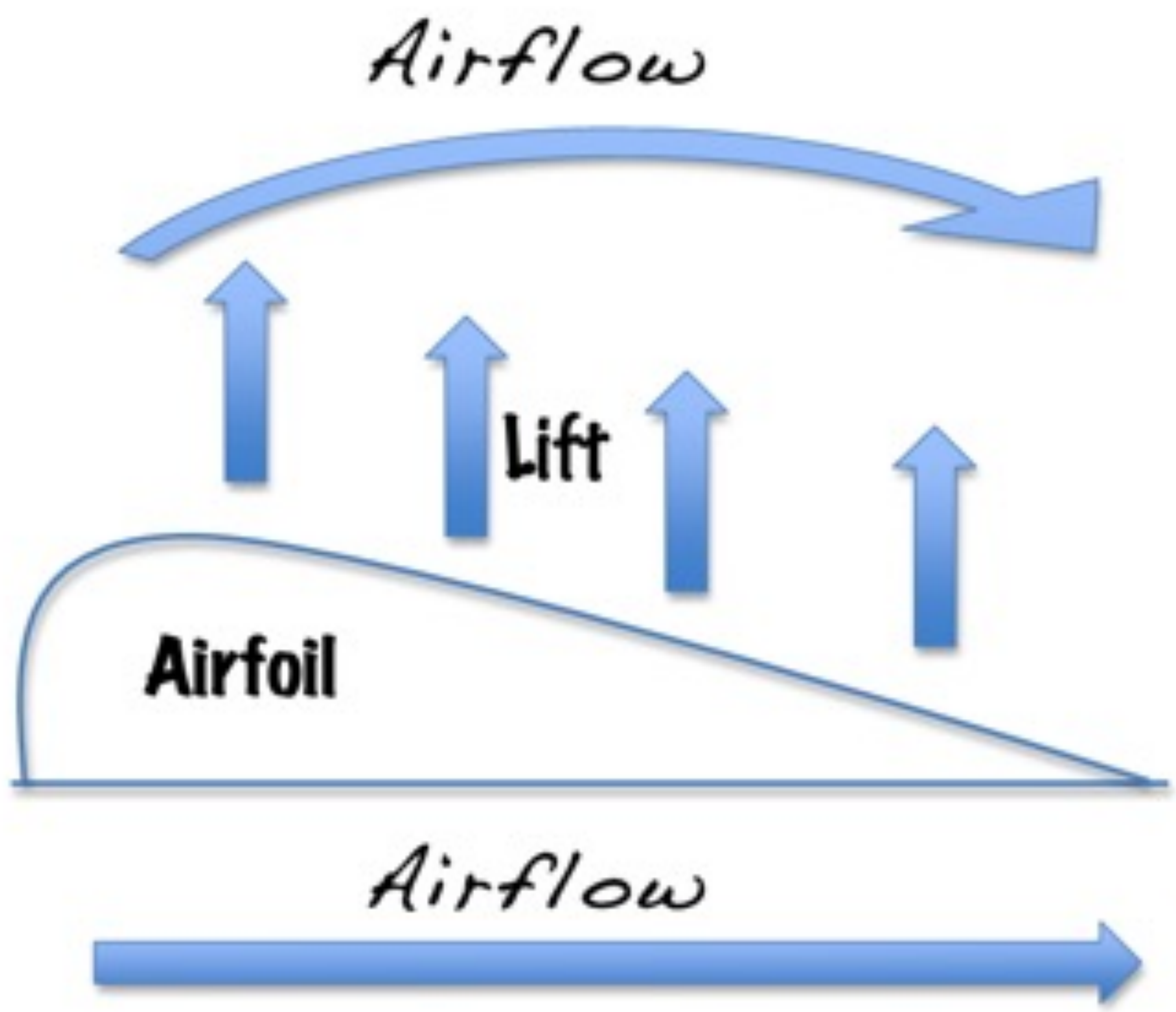
- As you can see in the diagram air passing just over the top of the wing is diverted by the wing being ‘in the way’ and this causes it to pass through a narrow gap in the same as it did in the wind tunnel example. This air speeds up – which causes pressure to drop above the wing. This means that as long as the plane is moving the air pressure above
- The wing is lower than below the wing, causing lift. The faster the plane moves, the greater this difference – and when an aeroplane is going fast enough this difference in pressure is enough to lift it into the air.



Aerofoil Activity | Wing, shape and lift

An aerofoil is a wing shape that can provide lift. Students will do an activity that will teach them about air pressure and how lift is created.

Bernoulli's principle: Bernoulli's principle helps explain that an aircraft can achieve lift because of the shape of its wings. They are shaped so that that air flows faster over the top of the wing and slower underneath. Fast moving air equals low air pressure while slow moving air equals high air pressure. The high air pressure underneath the wings will therefore push the aircraft up through the lower air pressure.



Resources

Activity Sheet
A4 Paper
60cm piece of string
Hole Punch
Tape

Aerofoil Activity | Wing, shape and lift

- Understand the idea of lift and how a wing's shape can affect it
- Learn what an aerofoil is

Method

- Pass out sheets of paper.
- Bend the paper in half lengthwise (don't put a fold in it). Tape the ends together. Punch a hole in the center of the rounded end. Put the string through the hole. This is an aerofoil.
- Predict what will happen to the aerofoil when you spin around.
- Hold the aero foil at arm's length holding each end of the string.
- Spin your body to see what will happen with the aerofoil.
- You can also use a hair dryer if the spin doesn't work.
- Record your observations.

Students will be surprised that the paper will float up. Going further: Make modifications with the shape of wing and see what happens.

Data Collection

Name.. Date ....

Prediction	Observation

Aerofoil Activity | Wing, shape and lift

- How did you hold your string to get the best result?

- What do we call the upward movement of the airfoil?

- What modifications could you make to your airfoil? Try it. What happened?

Your Task

Your main task is to design an aircraft focusing on Wing Design

Consider

- Structure/materials
- aerofoil shape
- wing configuration
- lift to drag ratio
- fuel economy

Include sketches and calculations and reasoning in your finished work

Your aircraft role will be to conduct strike missions, against a variety of targets and also support friendly ground forces with close air support and tactical reconnaissance.

The next sections will provide more information to help with your task.
Take notes/sketch before you design.

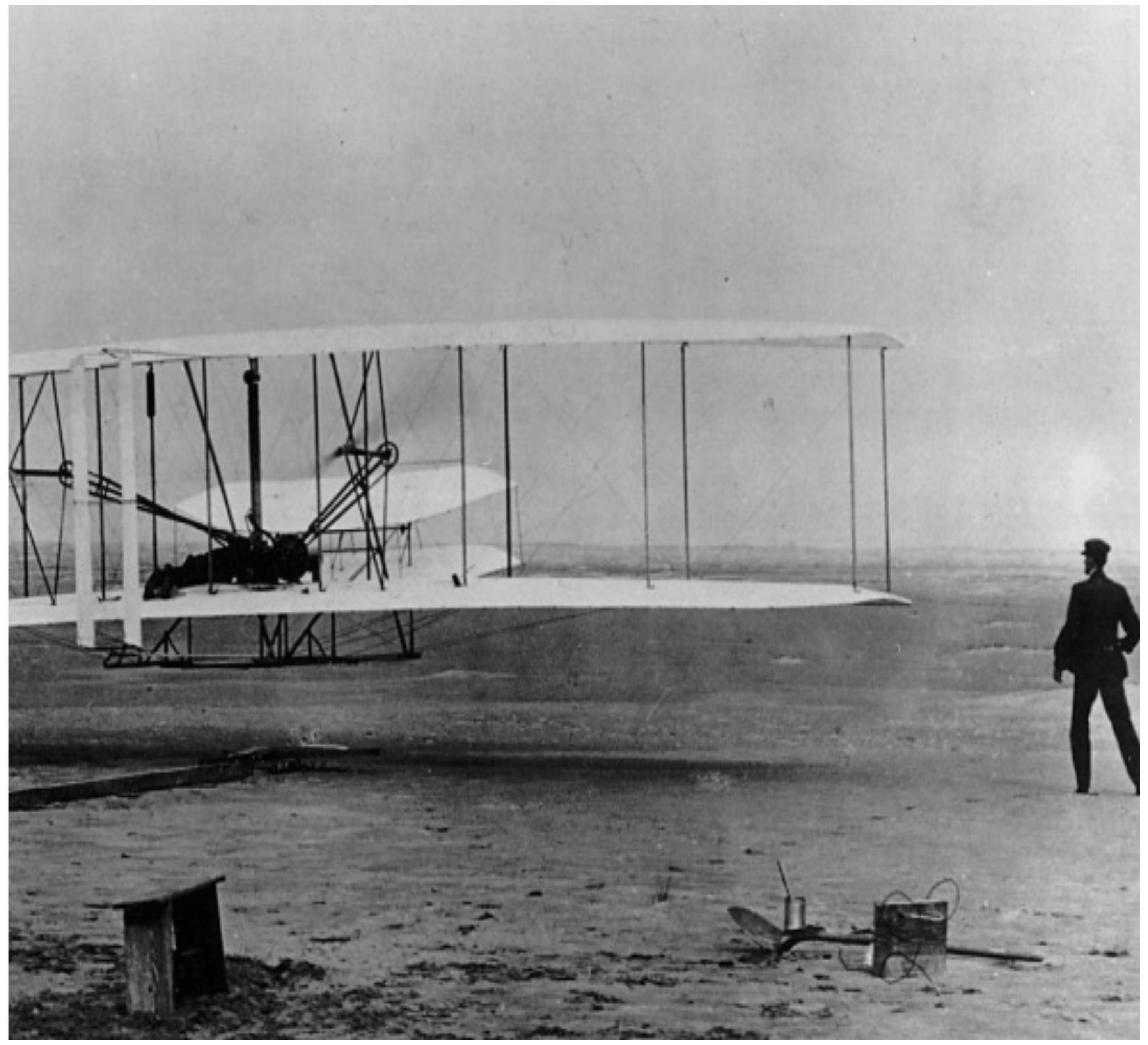
Wing Design | Structure

- Wing structures are a critical component in aerospace engineering, designed to provide lift and support to aircraft in flight.
- Engineered to balance aerodynamic efficiency, strength, and weight, incorporating materials like aluminum alloys and carbon-fibre composites.
- Understanding the principles behind wing structures is essential for grasping the fundamentals of aircraft design and performance.

Wing Design | Development

The Wright Brothers first wings were short and stubby. Eventually they found that a wing which was long and narrow was better for flying, generating much more lift and less drag.

- The effect of wing aspect ratio on the lift and drag is crucial
- A large aspect ratio wing is like a slat from a Venetian blind; a low aspect ratio wing is short and stubby
- The Wright Brothers found that a high aspect wing produced more lift and less drag than a low aspect wing. The aspect ratio for their next glider in 1902 was 6.7, and this glider flew beautifully. The Wright Flyer, the first powered aeroplane, had an aspect ratio of 6.4
- Many conventional airplanes today have very similar aspect ratios.



Wing Design | Development

- The shape of an aerofoil is an important design feature of a wing. The aerofoils used by the Wrights were very thin because their wind tunnel test indicated that very thin shapes resulted in lower drag than thick aerofoils. Most aeroplanes through the First World War followed suit and used thin aerofoils
- Thin aerofoils experienced “thin aerofoil stall” at angles of attack much lower than normal. This was due to the separation of the flow over the top surface of the thin aerofoil, creating a loss of lift
- The Fokker D.VII fighter climbed faster and manoeuvred more sharply than aeroplanes using thin aerofoils
- You can find the Fokker D.VII in Hangar 2.

Wing Design | Development

- In the 1920s aeroplane designers moved towards the use of thick aerofoils. By the 1930s, efficient wing designs exhibited large aspect ratios and thick aerofoils
- The famous Douglas Dakota is an excellent example, with its beautiful high wing aspect ratio of 9.14 and streamlined 15 percent thick aerofoil
- Thick aerofoils had structural as well as aerodynamic advantages
- A thicker wing allowed storage space for fuel tanks and retractable landing gear
- A thicker wing also allowed a larger and stronger structural spar along the inside of the wing, which in turn allowed the wing to be extended further from the fuselage without any external support wires and struts
- This helped to encourage the use of the modern single wing (monoplane) instead of the older two-wing (biplane) configuration.

Wing Design | Development

- With the advent of jet aeroplanes in the 1950s pushing speeds close to and beyond the speed of sound, aerofoil and wing shapes made another dramatic change
- Thinner aerofoils allowed slower-than-the-speed-of-sound (subsonic) aeroplanes to fly closer to the speed of sound before encountering shock waves over the wing, which would greatly increase the drag and reduced the lift.
- The Hawker Hunter FGA9 in Hangar 3 was one of the most successful of the British post-war jet fighters; over 1000 were purchased by the Royal Air Force.

Wing Design | Development

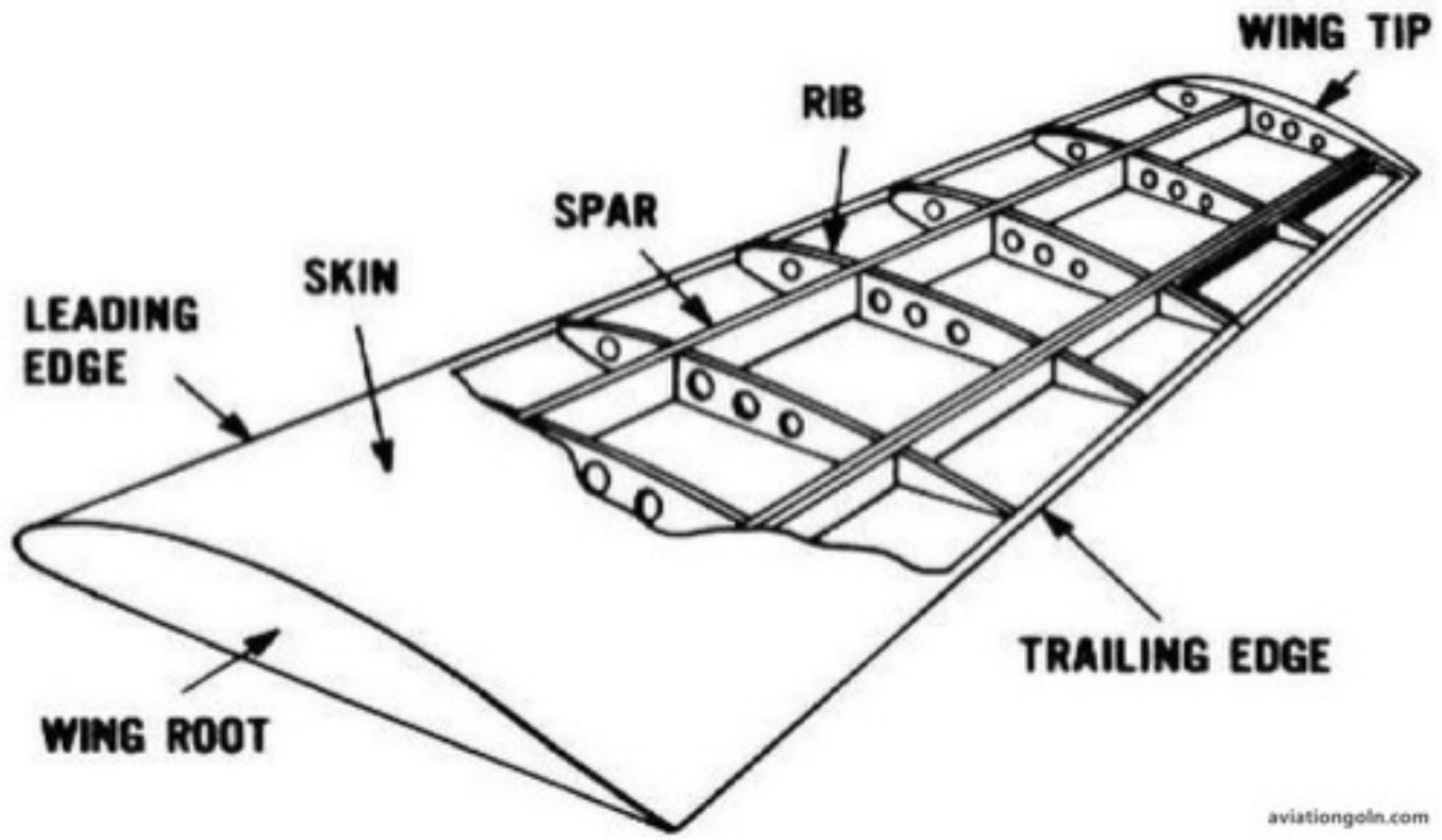
- For supersonic aeroplanes, the driving design feature is to reduce the strength of shock waves on the wings, and hence to reduce the supersonic wave drag.
- he thinner the aerofoils, the weaker the shocks, and the lower the wave drag.
- The Lockheed Martin F35B Lightning II is an example.
- The F-35 is a stealthy, multi-role, all-weather, day and night fighter/attack aircraft that can operate from land bases and aircraft carriers.

Wing Structure

- The particular design of the wings for any aircraft depends on several factors including the desired speed at takeoff, landing and in-flight, the desired rate of climb, use of the aeroplane, and size and weight of the aircraft.
- Aircraft wings are often of complete cantilever design. What this means is that they are built in such a way that they don't require any external bracing. They are internally supported.
- In some aircraft wings, external wires or struts are used to support the wing and carry the landing and aerodynamic loads. Wing support struts and cables are mostly made from steel.

Wing Structure

- Wings are mostly constructed using aluminium, but they can also be made using wood covered with fabric. Some aircraft wings are made using a magnesium alloy. In modern aircraft, stronger and lighter materials are used in wing construction and throughout the airframe.
- Wings made of carbon fibre now widely used, wth access to a combination of materials to provide maximum strength.
- The internal structures of aircraft wings are usually made of stringers and spars running spanwise and formers or bulkheads and ribs running chordwise – leading edge to trailing edge.



Wing Types | Rectangular wing

- The rectangular wing is the simplest to manufacture. It is a non-tapered, straight wing that is mostly used in small aircrafts. This wing extends out from the aircraft's fuselage at right angles
- A good example of an aircraft where a rectangular wing was used is the Piper PA 38. One major disadvantage of a rectangular wing is that it isn't aerodynamically efficient

Record aspects you may use in your design.

Wing Types | Elliptical wing

- The elliptical wing is aerodynamically most efficient because they induce the lowest possible drag. However, the manufacturability of this aircraft wing is poor.
- One of the most famous aircraft with elliptical wings was the Supermarine Spitfire that ruled the skies during the Battle of Britain
- The elliptical wing wasn't originally designed to minimize drag induction, but rather it was made to house the landing gear along with ammunition and guns inside a wing. So, the wing had to be thin.
- The ellipse was the shape that allowed for the thinnest possible wing, giving room inside to hold the necessary things.
- The Supermarine Spitfire 1 can be found in Hangar 3
- Record and sketch key aspects aspects for your design

Wing Types | Tapered wing

- The tapered wing was designed by modifying the rectangular wing. The wing is reduced in width from the fuselage to the wingtip.
- While it isn't as efficient as the standard elliptical wing, it does offer a compromise between efficiency and manufacturability.
- The Westland Lysander has a tapered wing. It was originally designed for Army Co-operation duties including artillery spotting and reconnaissance but also used as a Special Duties aircraft ferrying Allied agents in and out of enemy occupied Europe.
- You can find the Lysander in Hangar 5

Record features for your design

Wing Types | Delta wing

- This low aspect ratio wing is used in supersonic aircraft. The main advantage of a delta wing is that it is efficient at all speeds. Moreover, this type of wing offers a large area for the shape thereby improving maneuverability and reducing stress.
- The delta wing doesn’t just offer efficient flight experience but is also strong structurally and provides large volume for fuel storage. This wing is also simple to manufacture and maintain.
- Due to their low aspect ratio, delta wings induce high drag.
- At low speed – during landing and takeoff –, these wings have to be flown at a higher angles.
- A variant of delta wing is the cropped delta and it is seen in the Eurofighter Typhoon that can be seen in H6. The tips of this variant are cut off for reducing drag at low speeds.

Sketch/record advantages to use in your design

Wing Types | Trapezoidal wing

- This is a high performance wing design used in the Lockheed Martin F35B Lightning II
- The design allows for a thin wing width and low drag at high speeds while maintaining high strength and stiffness.
- Short tapered wings with little overall sweep result in a leading edge that sweeps back and a trailing edge that sweeps forward
- This configuration is particularly effective for supersonic flight when engine power is limited and has been adopted for modern combat fighters.
- It is lightweight, efficient at speed, and manoeuvrable.

Wing Types | Swept-back wings

- The aircraft wings whose leading edges are swept back are called swept-back wings.
- Swept-back wings reduce drag when an aircraft is flying at transonic speeds.
- The Panavia Tornado GR1B is an example that uses swept back wings that can be found in Hangar 6.

Activity | Compare and contrast wing designs

Sketch aircraft 1

Activity | Compare and contrast wing designs

Sketch aircraft 2

Your Task

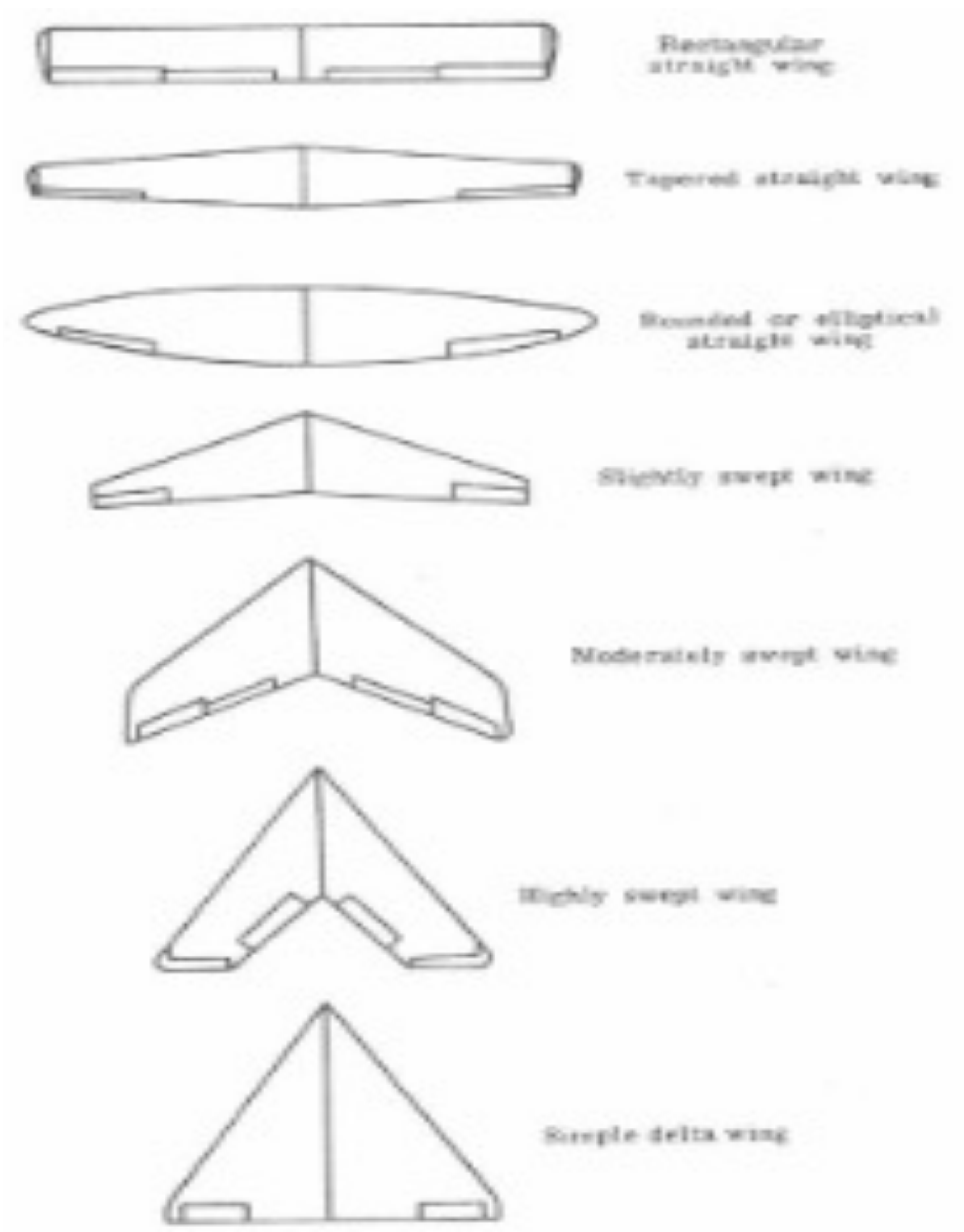
Your main task is to design an aircraft focusing on Wing Design

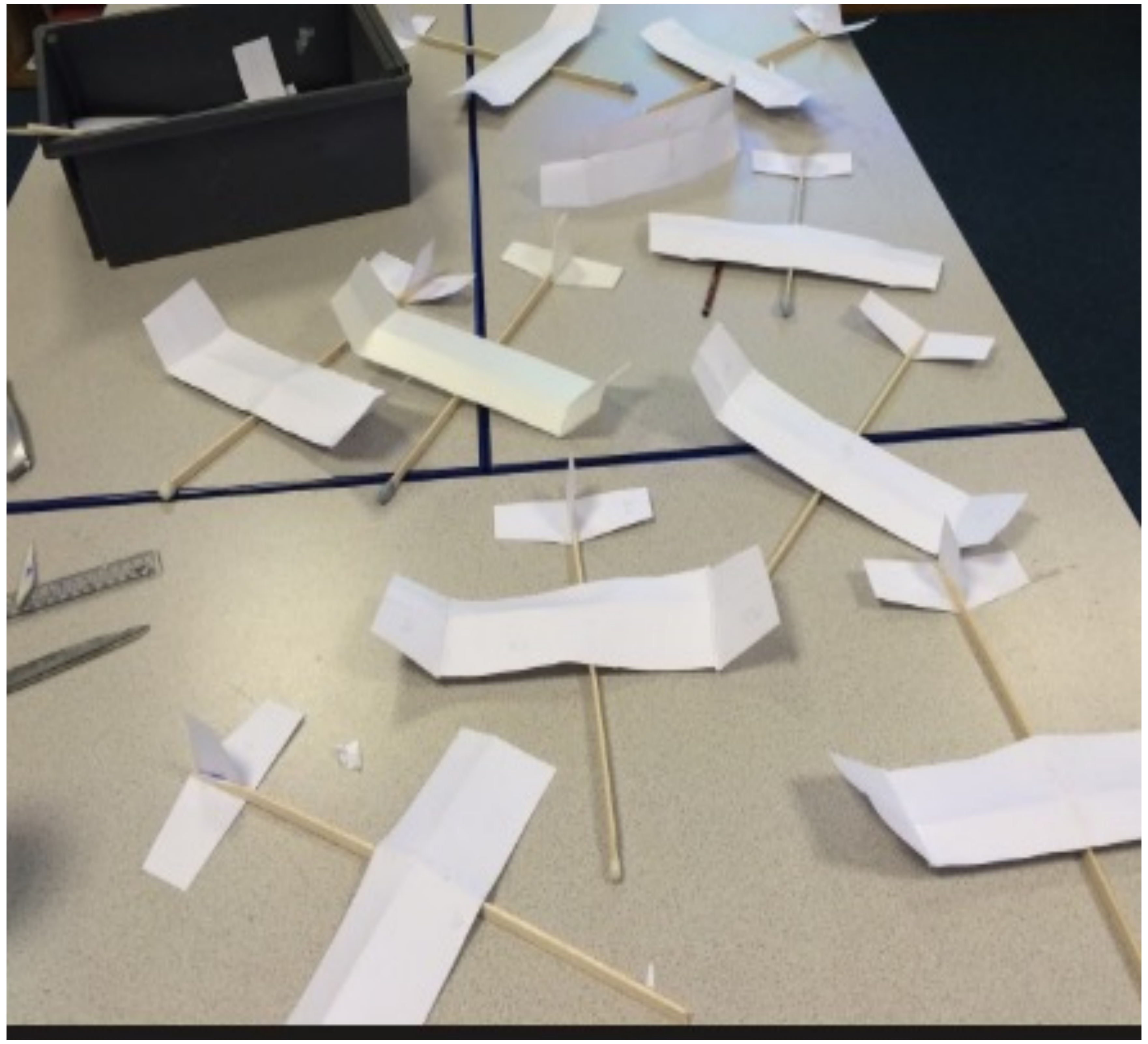
Consider

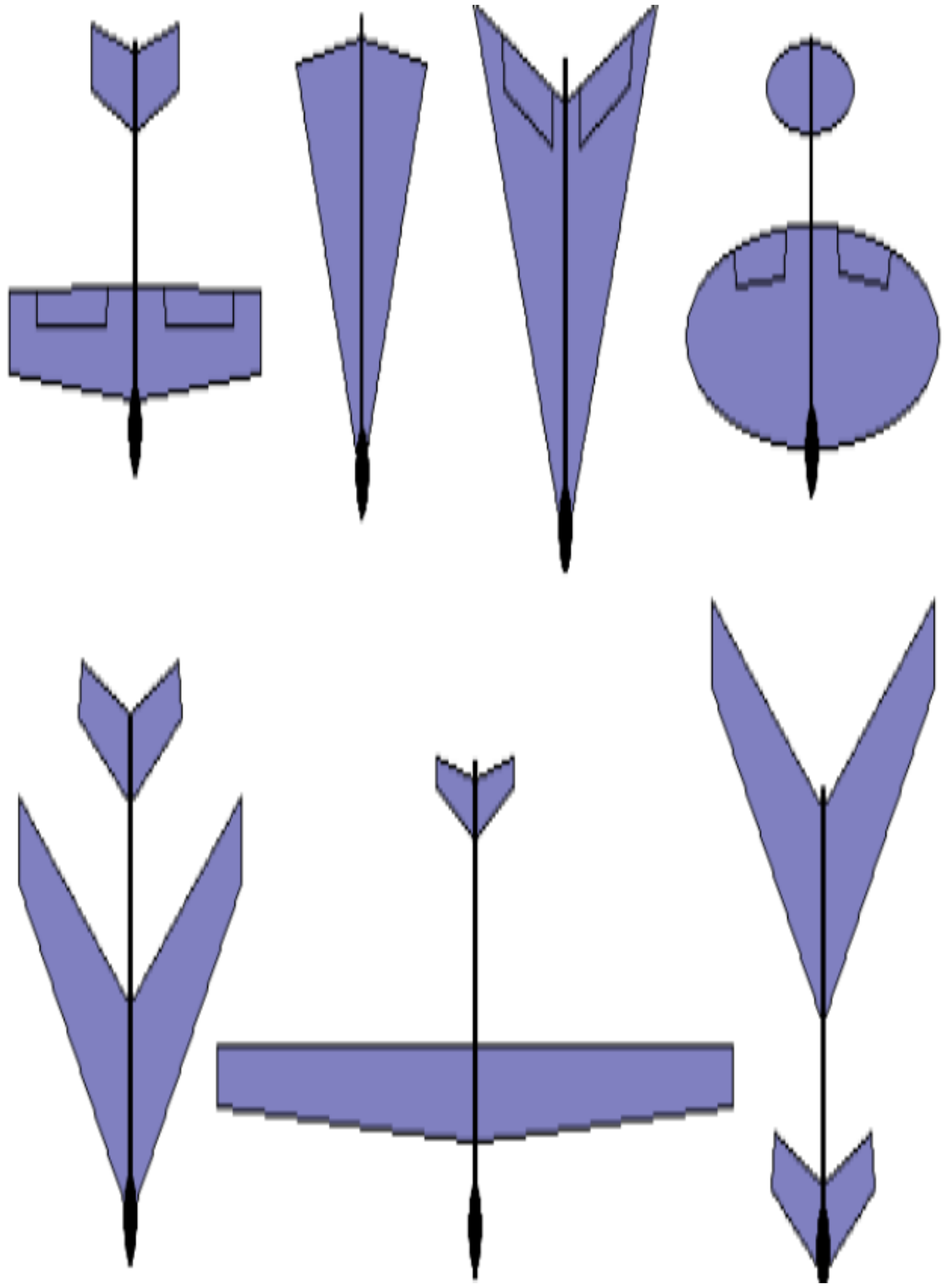
- Structure/materials
- Aerofoil shape
- Wing configuration
- Lift to drag ratio
- Fuel Economy

Include sketches and calculations and reasoning in your finished work
Your aircraft role will be to conduct strike missions, against a variety of targets and also support friendly ground forces with close air support and tactical reconnaissance.

Wing Inspiration







Your Task

- Using any resources you can obtain at home, make a model of your Wing Design.
- You could use paper, card or recycled materials, or you could try using materials like balsa wood.
- When aircraft engineers develop new designs they test them. This is the iterative design process that engineers go through to solve problems.
- By building and testing a prototype, engineers are able to look at what worked and what didn't. This is something you might do with your design.