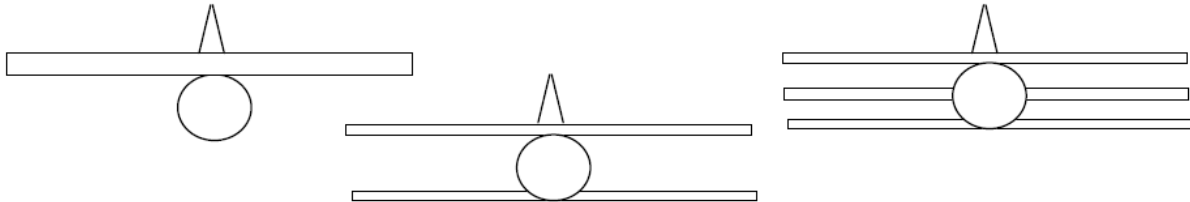


## CLASSIFICATIONS OF FLIGHT VEHICLES (unit-3)

### CLASSIFICATION BASED ON WINGS

1. Monoplane (i.e. one wing)
2. Two wings (i.e. biplane)
3. Three wings



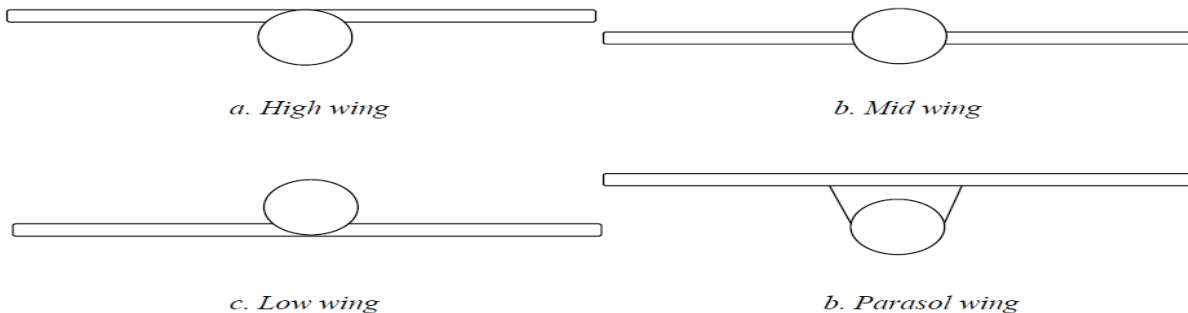
1. Monoplane

2. Biplane

3. triwing

- ❖ Nowadays, modern aircraft almost all have monoplane.
- ❖ Currently, there are a few aircraft that employ biplane
- ❖ In the past, the major reason to select more than one wing was the manufacturing technology limitations.
- ❖ A single wing usually has a longer wing span compared with two wings (with the same total area).
- ❖ Old manufacturing technology was not able to structurally support a long wing to stay level and rigid.
- ❖ With the advance in the manufacturing technology and also new aerospace strong materials; such as advanced light aluminum, and composite materials; this reason is not valid anymore.
- ❖ Another reason was the limitations on the aircraft wing span. Hence a way to reduce the wing span is to increase the number of wings.
- ❖ Several maneuverable aircraft in 1940s and 1950s had biplane and even three wings.
- ❖ The disadvantages of biplane are offer higher weight, lower lift, and pilot visibility limits.

### CLASSIFICATION BASED ON WINGS POSITION



### **A. Advantages of High Wing**

1. The aircraft structure is lighter when struts are employed
2. Increases the dihedral effect. It makes the aircraft laterally more stable
3. Increases the dihedral effect. It makes the aircraft laterally more stable
4. Increases the dihedral effect. It makes the aircraft laterally more stable
5. There is a lower possibility of human accident

#### **Disadvantages:**

1. The aircraft have more frontal area which increases drag.
2. The wing is producing more induced drag.
3. A high wing is structurally about 20% heavier than a low wing.
4. The aircraft lateral control is weaker compared with mid wing and low wing

### **B. Advantages of Low Wing**

1. Aircraft frontal area is less.
2. The wing has less induced drag.
3. The tail is lighter; compared with a high wing configuration
4. The aircraft take off performance is better

#### **Disadvantages of Low Wing**

1. The aircraft has a lower landing performance
2. The wing generates less lift
3. The aircraft has lower airworthiness due to a higher stall speed.

### **C. Features of a mid-wing configuration**

1. The aircraft structure is heavier
2. The mid wing is more expensive compared with high and low-wing configurations.
3. The mid wing is aerodynamically streamliner compared with two other configurations
4. The mid-wing has less interference drag than low-wing and high-wing.

### **CLASSIFICATION BASED ON MACH NUMBER**

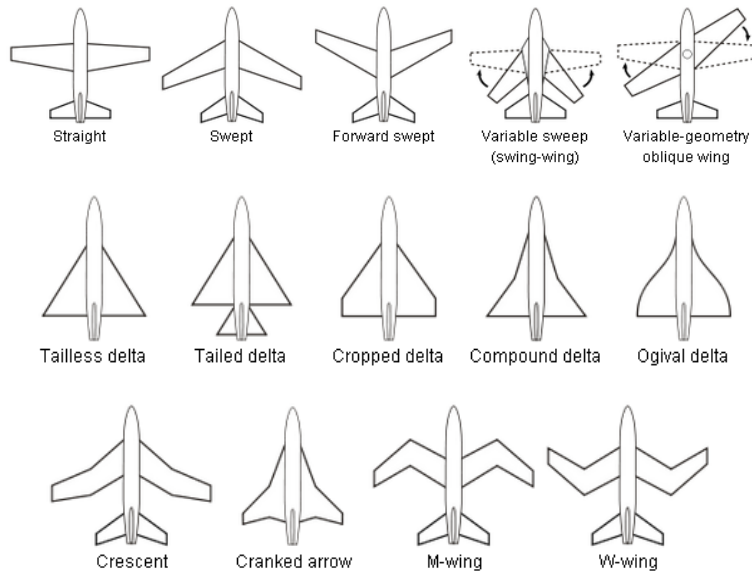
Aircraft are classified based on their maximum Mach number,

- Subsonic ( $M < 1$ )
- Transonic ( $M \sim 1$ )
- Supersonic ( $M > 1$ )
- Hypersonic ( $M \gg 1$ )

### **CLASSIFICATION BASED ON PURPOSE**

- Military aircraft
  - » Fighters
  - » Bombers
  - » Medical / Rescue Aircraft
  - » Spy / Reconnaissance Aircraft

# SWEEP WING



## CLASSIFICATION BASED ON PURPOSE

- Agricultural aircraft
- Sports aircraft
- » Glider
- » Recreational aircraft
- » Man-powered aircraft

## CLASSIFICATION BASED ON TYPE OF ENGINE

Aircraft with engine are classified based on the type of engine as follows,

- Propeller
- Turboprop
- Turbofan
- Turbojet
- Ramjet

## CLASSIFICATION BASED ON RANGE

Aircraft are classified based on their range as follows,

- Short range (<500 km)
- Medium range (<3000km)
- Long range (>3000 km)

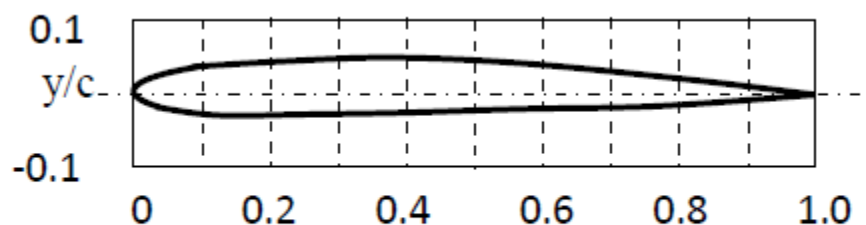
## NACA Airfoils

Three following groups of NACA airfoils are more interesting:

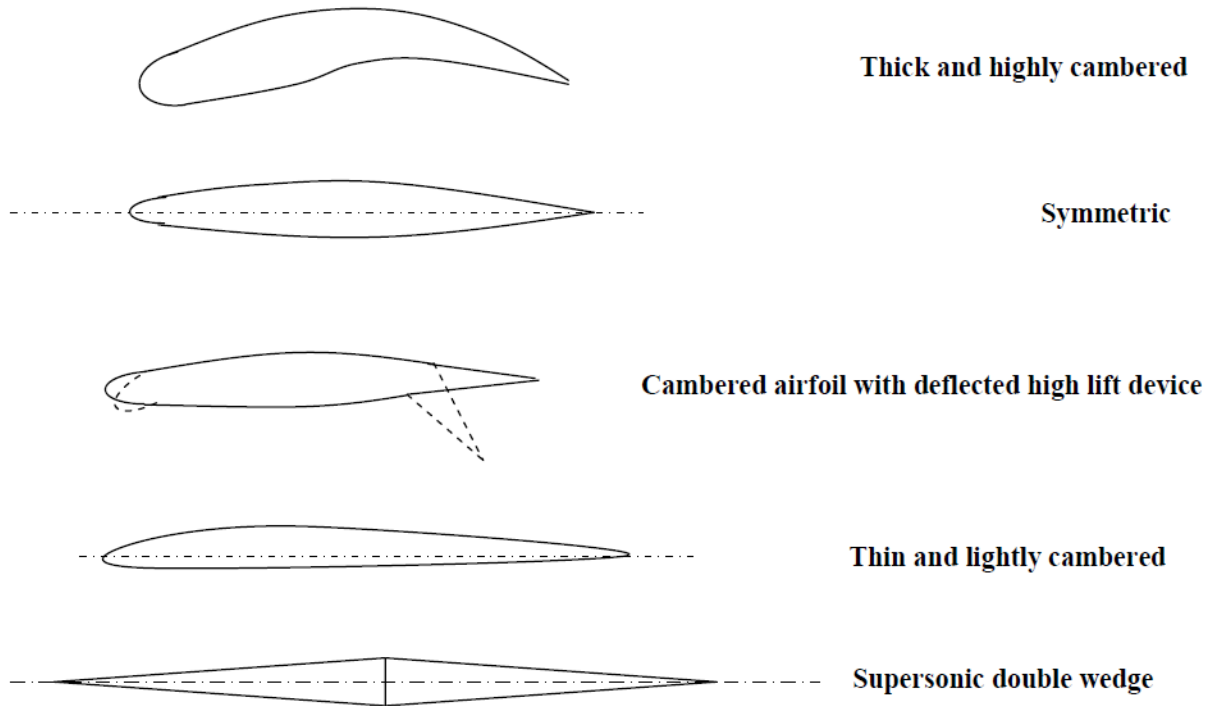
- Four-digit NACA airfoils
- Five-digit NACA airfoils
- 6-series NACA airfoils

### Four-digit NACA airfoils

1. The four-digit NACA airfoil sections are the oldest and simplest NACA airfoils to generate.
2. The camber of a four-digit airfoil has made up of two parabolas. One parabola generates the camber geometry from the leading edge to the maximum camber, and another parabola produces the camber shape from the maximum camber to the trailing edge.
3. In a Four-digit NACA airfoil, the first digit indicates the maximum camber in percent chord.
4. The second digit indicates the position of maximum camber in tenths of chord length.
5. The last two digits represent the maximum thickness-to-chord ratio.
6. A zero in the first digit means that this airfoil is a symmetrical airfoil section.
7. For example, the NACA **1408** airfoil section has a 8 percent ( $t/c$ )<sub>max</sub> (the last two digits), its maximum camber is 10 percent, and its maximum camber is located at 40 percent of the chord length. Although these airfoils are easy to produce, but they generate high drag compared with new airfoils



*a. NACA 1408 airfoil section*

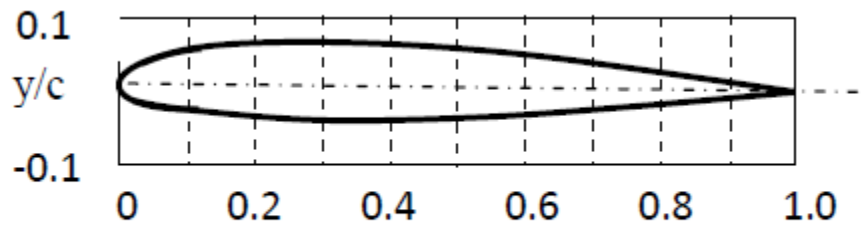


*Figure 5.18. Five sample airfoil sections*

### **Five-digit NACA airfoils**

1. The camber of a five-digit airfoil section has made up of one parabola and one straight line.
2. The parabola generates the camber geometry from the leading edge to the maximum camber, and then a straight line connects the end point the parabola to the trailing edge.
3. In a five-digit NACA airfoil section; the first digit represents the  $2/3$  of ideal lift coefficient in tenths.
4. It is an approximate representation of maximum camber in percent chord.
5. The second digit indicates the position of maximum camber in two hundredths of chord length.
6. The last two digits represent the maximum thickness-to-chord ratio.
7. A zero in the first digit means that this airfoil is a symmetrical airfoil section.
8. For example, the NACA **23012** airfoil section (see figure 5.19b) has a 12% maximum thickness-to-chord ratio;  $(t/c)_{\max}$ . The ideal lift coefficient of this airfoil is 0.3 (the second digit), since  $2/3$

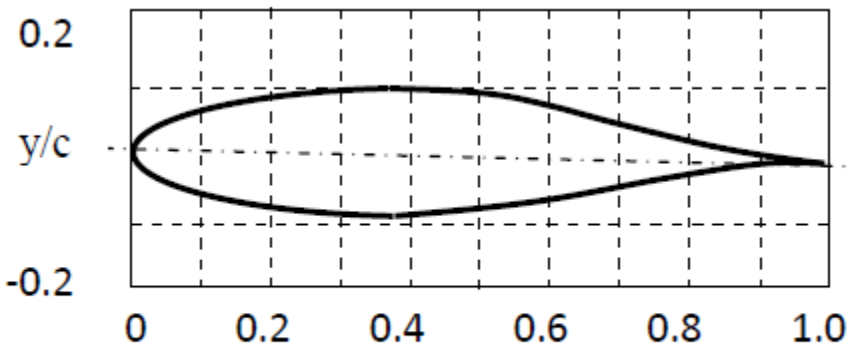
$\times C_{li} = 2/10$ , thus,  $C_{li} = 0.2/(2/3) = 0.3$ . Finally its maximum camber is located at 12% of the chord length.



*b. NACA 23012 airfoil section*

### The 6-series NACA airfoils

1. The four- and five-digit airfoil sections were designed simply by using parabola and line.
2. They were not supposed to satisfy major aerodynamic design requirements, such as laminar flow and no flow separation.
3. The six series airfoils were designed to maintain laminar flow over a large part of the chord
4. The 6-series NACA airfoils are designated by five main digits and begin with number 6.
5. Some 6-series airfoils have a subscript number after the second digit. There is also a “-“ between the second digit and the third digit.



*c. NACA 63<sub>3</sub>-218 airfoil section*