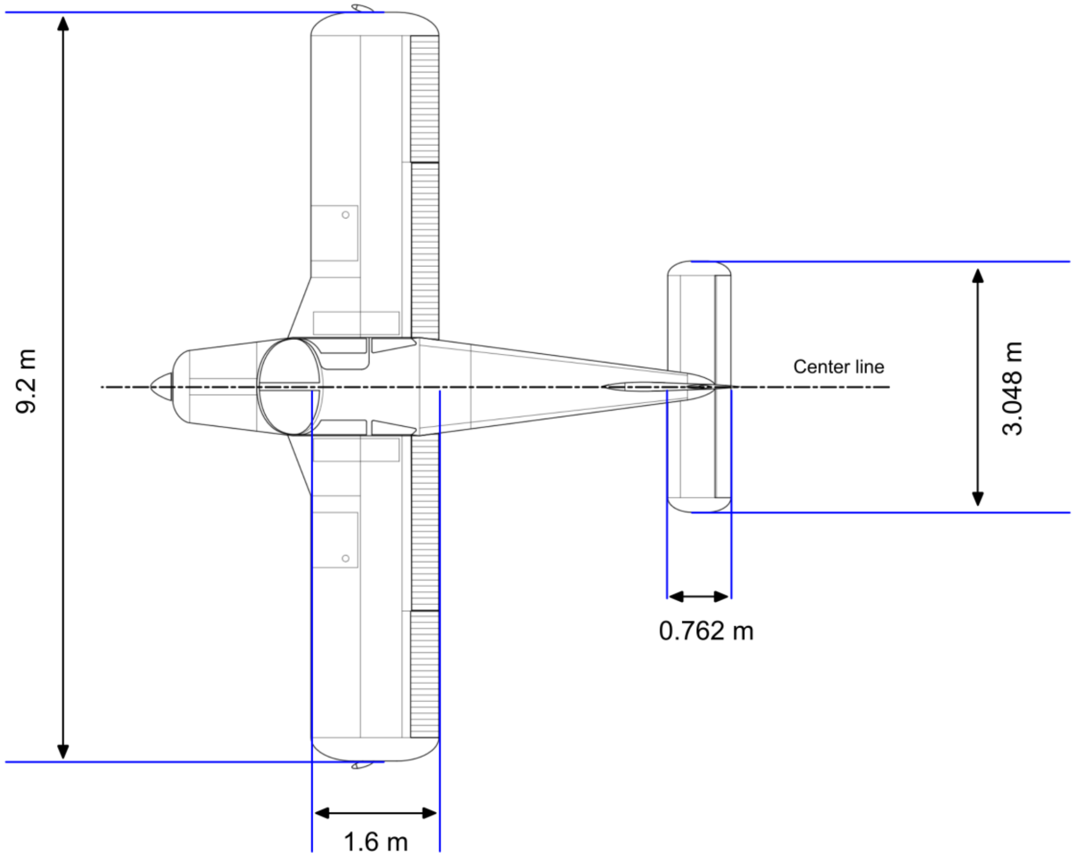
Exercise using the wing planform of an actual aircraft

- Your task is to:
  - Compute manually the wing aspect ratio, taper ratio, and planform area.
  - Design the wing planform in XFLR5.



- Wing section:
  - NACA 65_2-415
- Incidence angle (angle at the wing's root):
  - $i_w = 2^\circ$
- Neither geometrical twist nor aerodynamic twist.
- Dihedral angle → 7°
- Monoplane – Cantilever low wing

Note: the dimensions shown are based on actual drawings. They are not the official manufacturer dimensions.

Exercise using the wing planform of an actual aircraft

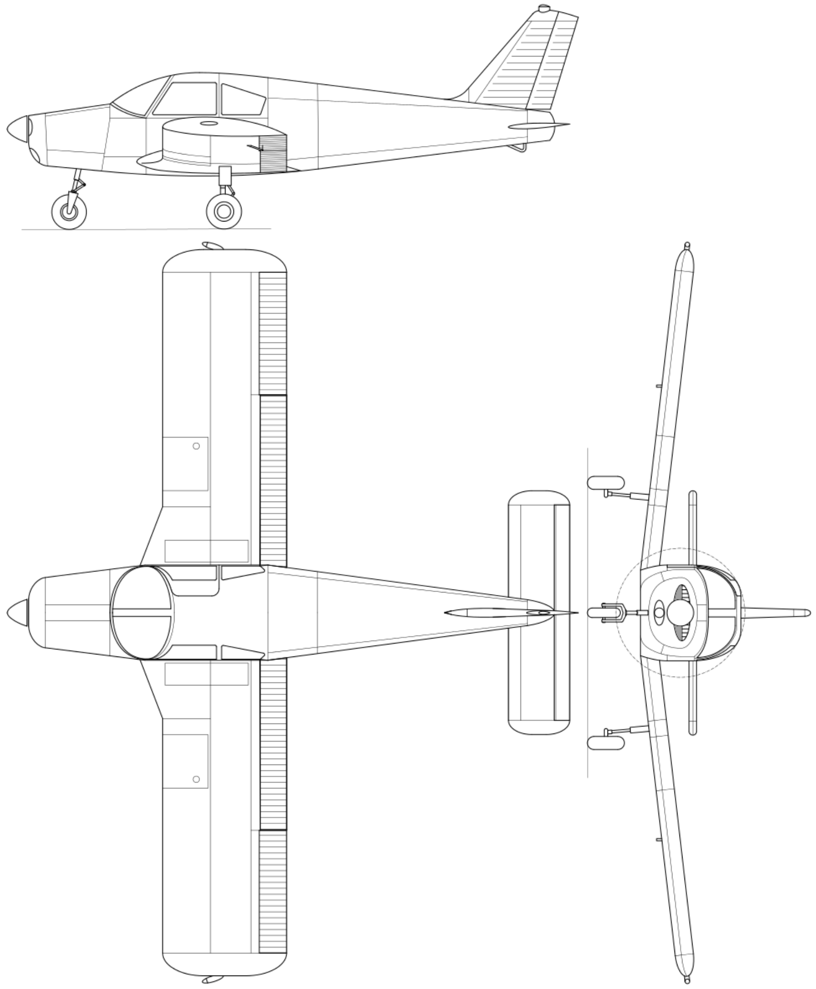
- Using the following information (taken from the POH),
    - Maximum take-off weight: 2400 lbs or approximately 1085 kg
    - Max cruise speed: 216 kph (60 m/s)
    - Maximum operation speed at sea level: 240 kph (66.6 m/s)
    - Stall speed: 92 kph (25.5 m/s)
    - Service ceiling: 4000 m

- Using the LLT method and ignoring the dihedral angle, you are asked to determine if this wing will generate the required lift to fly at an altitude of 1000 m and at the maximum cruise speed.
- At what AOA you will need to fly if the cruise velocity is kept constant at 55 m/s and you climb to 2000 m?
- What would you do to generate the required lift at sea level, max. cruise speed, and at an AOA of 0°? You are free to change any wing geometry parameter.
- Reminder:

$$L = \frac{1}{2} \times \rho \times V^2 \times S_{ref} \times C_L \qquad D = \frac{1}{2} \times \rho \times V^2 \times S_{ref} \times C_D$$

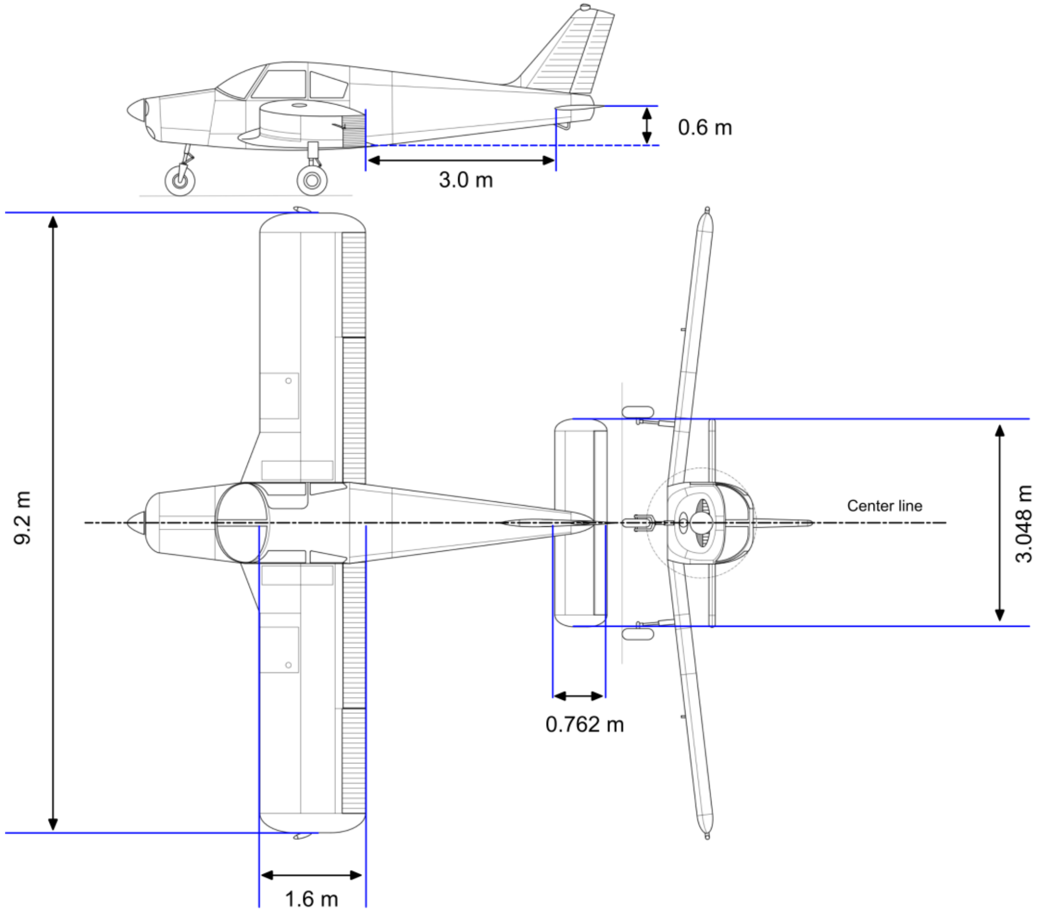
Exercise using the wing planform of an actual aircraft

- This sample exercise corresponds to the Piper PA-28 Cherokee.
- A very popular general aviation aircraft.



Exercise using the wing planform of an actual aircraft

- Let us go for the extra mile.
- We will add the elevator and we will see what happens with the aerodynamic performance.
- Pay particular attention to the moment coefficient.
- Remember, the basic LLT method in XFLR5 does not work with multiple surfaces; therefore, we will use the Vortex Lattice Method (VLM).

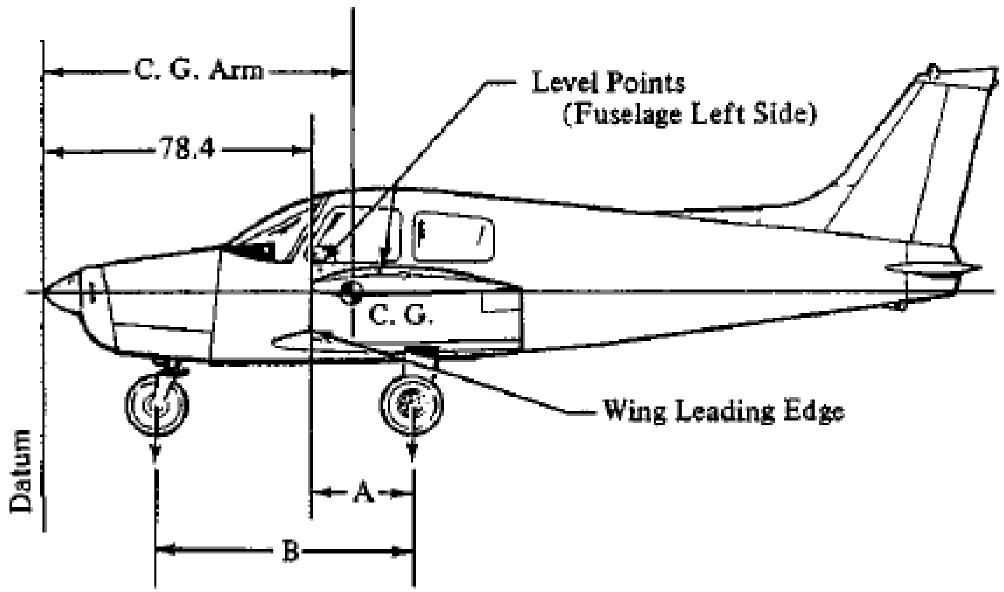


- Elevator section:
  - NACA 0012
- Incidence angle:
  - $i_w = 0^\circ$
- Neither geometrical twist nor aerodynamic twist.

Note: the dimensions shown are based on actual drawings. They are not the official manufacturer dimensions.

Exercise using the wing planform of an actual aircraft

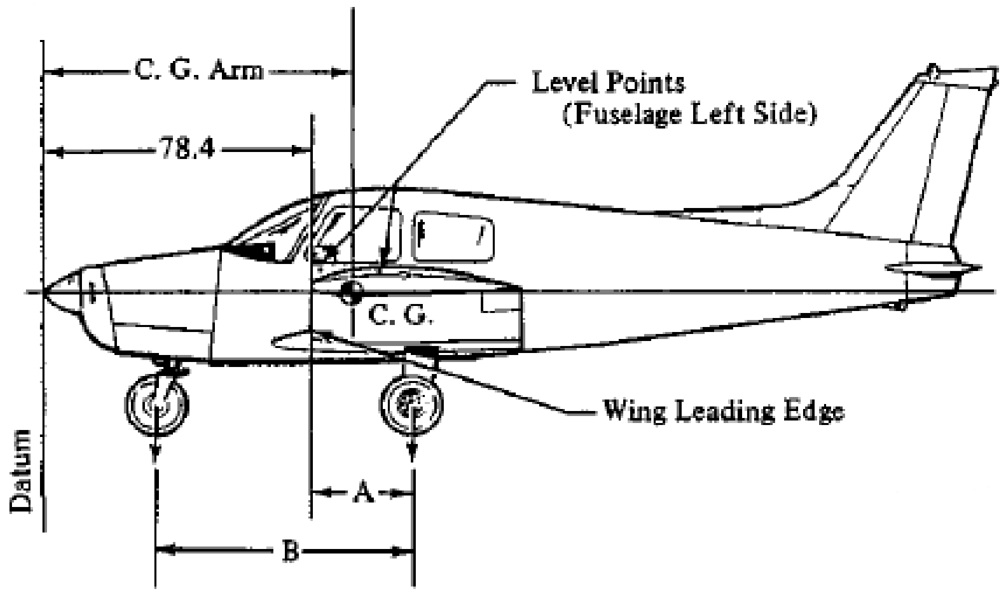
- For balancing (or trimming) the aircraft, we must know the position of the center of gravity.
- Aircraft are very sensitive to CG location, in particular small ones.
- Let us assume that the CG is located 85.2 inches (≈ 216 cm) from the datum.
- This CG location corresponds to the Licensed Empty Weight of the airplane (1275 lbs or ≈ 578 kg).
- You are asked to trim the aircraft in cruise conditions.



The datum is 78.4 inches (≈ 199 cm) ahead of the wing leading edge at the intersection of the straight and tapered section

Exercise using the wing planform of an actual aircraft

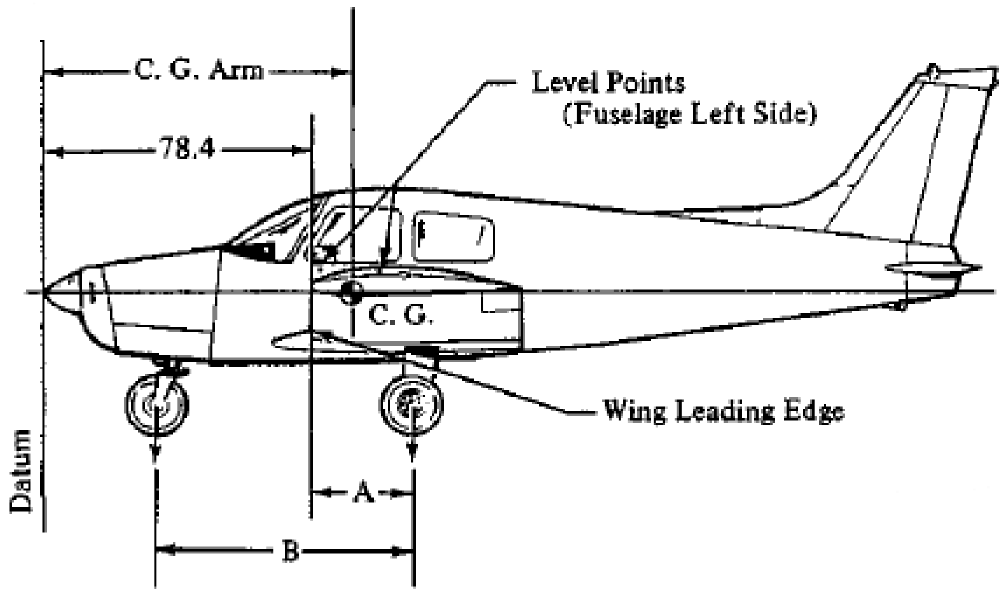
- For balancing (or trimming) the aircraft, we must know the position of the center of gravity.
- Aircraft are very sensitive to CG location, in particular small ones.
- Let us assume that the CG is located 93.2 inches (≈ 236 cm) from the datum.
- This CG location corresponds to a total weight of the airplane of 2400 lbs (≈ 1085 kg), the maximum certified take-off weight.
- You are asked to trim the aircraft in cruise conditions.



The datum is 78.4 inches (≈ 199 cm) ahead of the wing leading edge at the intersection of the straight and tapered section

Exercise using the wing planform of an actual aircraft

- The previous information related to the aircraft general specifications (weight, cg location, ceiling, cruise velocity, and so on) was taken from the pilot operating handbook of the aircraft manufacturer.
- The dimensions in the figure below are given using the US customary units, as per the pilot operating handbook of the aircraft manufacturer.
- Also note that we gave two CG locations. One corresponds to the licensed empty weight of the aircraft (we are not taking into account payload) and the other one corresponds to the maximum take-off weight.
- Different CG locations will result in different trim conditions.



The datum is 78.4 inches (≈ 199 cm) ahead of the wing leading edge at the intersection of the straight and tapered section