Module-2

Lecture-4

Introduction to Performance of Flight and Experiments
Performance of flight

Module Agenda

• Aerodynamic nomenclature used for flight performance

• Definition of forces, in steady and symmetrical straight line flight

• Cruise flight
  Thrust and power required
  Thrust and power available
  Maximum flight velocity
  Altitude effects on power available and power required
  Range and endurance.

• Climb performance
  Maximum angle of climb
  Maximum rate of climb
  Altitude effects on power available and power required

• Estimation of profile Drag coefficient \( C_{D_e} \) and Oswalds efficiency \( e \) of an aircraft from experimental data obtained is steady and level flight.
Aerodynamic nomenclature used for flight performance

![Figure 1: Definition of angles, axes and velocities in steady, symmetrical and straight line flight](image)

- $V$: Air relative velocity of airplane
- $X_b$: Body fixed $X$-axis (Along fuselage reference or chord line)
- $X_s$: Stability axis $X$-axis ($X_s$-axis align along the air relative velocity)
- $Z_b$: Body fixed $Z$-axis
- $Z_s$: Stability axis $Z$-axis
- $\alpha$: Angle of attack, defined as the angle between $X_b$ and the horizon
- $\theta$: Airplane pitch attitude angle, defined as the angle between $X_b$ and the horizon
- $\gamma$: Flight path angle, defined as the angle between $V$ and the horizon
- $V_v$: Vertical-velocity component, also known as the rate-of-climb
- $V_h$: Horizontal-velocity component
- $\phi_T$: Thrust force inclination, defined as the angle between $X_b$ and the thrust line of action ($\phi_T$ is Zero in Figure 1)
- $RC$: Rate of Climb
Definition of forces, in steady and symmetrical straight line flight

In flight an airplane, can be said to be under the influence of four main forces:

1. The Lift, $L$, acting vertically upwards and is perpendicular to the air relative velocity.

2. The Weight of the airplane, $W$, acting vertically downwards through the centre of gravity.

3. The Thrust $T$, delivered by the engine or engine(s).

4. The Drag, $D$, acting in the direction opposite to the air relative velocity.

These forces are depicted in Figure 2.

Figure 2: Definition of forces in steady, symmetrical and straight line flight