Module-6

Lecture-25

Various Coordinate System

Various Coordinate System

Aerodynamic coordinate system

- With respect to a 2- Dimensional flow problem (airfoil cross section) Figure 1, x - axis is assigned to the general flow direction with origin at nose of the body under consideration.
- y - axis is naturally chosen normal to the x-axis in the upward direction.

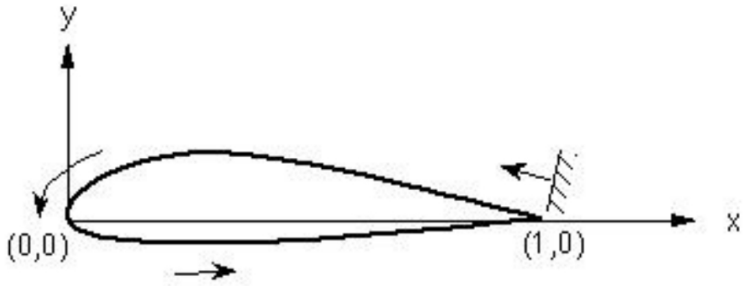

Figure 1: Airfoil Coordinate System

- Now, extending the flow field in 3- dimension, a conventional right-handed system predicts z - axis to be pointing in the spanwise direction.
- This coordinate system is referred to as aerodynamic coordinates.
- **Disadvantages:**
  - Since aerodyanamic coordinate system is fixed to the aircraft, the position and orientation of the aircraft can't be described in terms of aerodynamic coordinates.

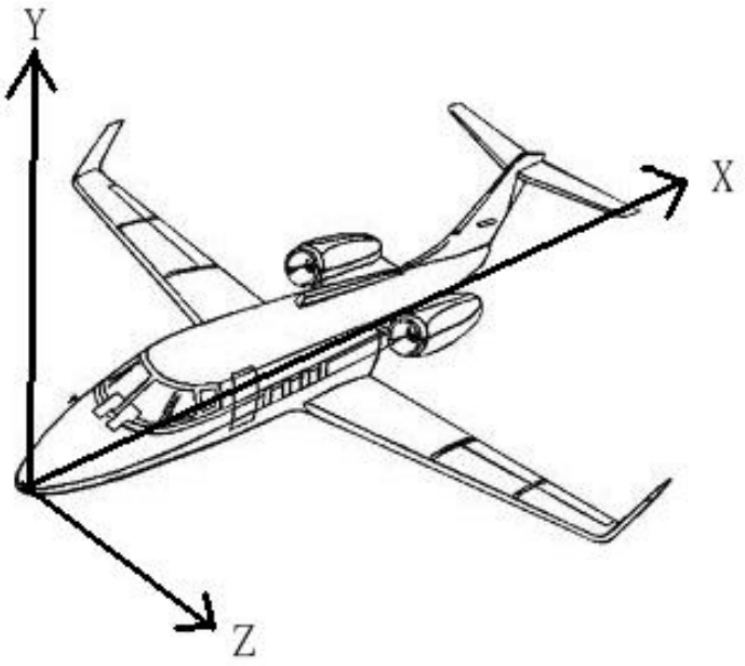

Figure 2: Aerodynamic coordinate system

Earth fixed coordinate system

- Position and Orientation of an aircraft are expressed in terms of an earth fixed coordinate system.
- $(x_f - y_f)$ plane is normal to the local gravitation vector with x_f - axis pointing east and the y_f – axis pointing north.
- z_f - axis points up, completing the right handed Cartesian system.
- This coordinate system is also known as inertial coordinate system under the following assumptions.
    - Radius of earth is very large compared to distance traveled by an aircraft.
    - Earth is assumed to be flat.
    - Effects due to earth's rotation and revolution are neglected.

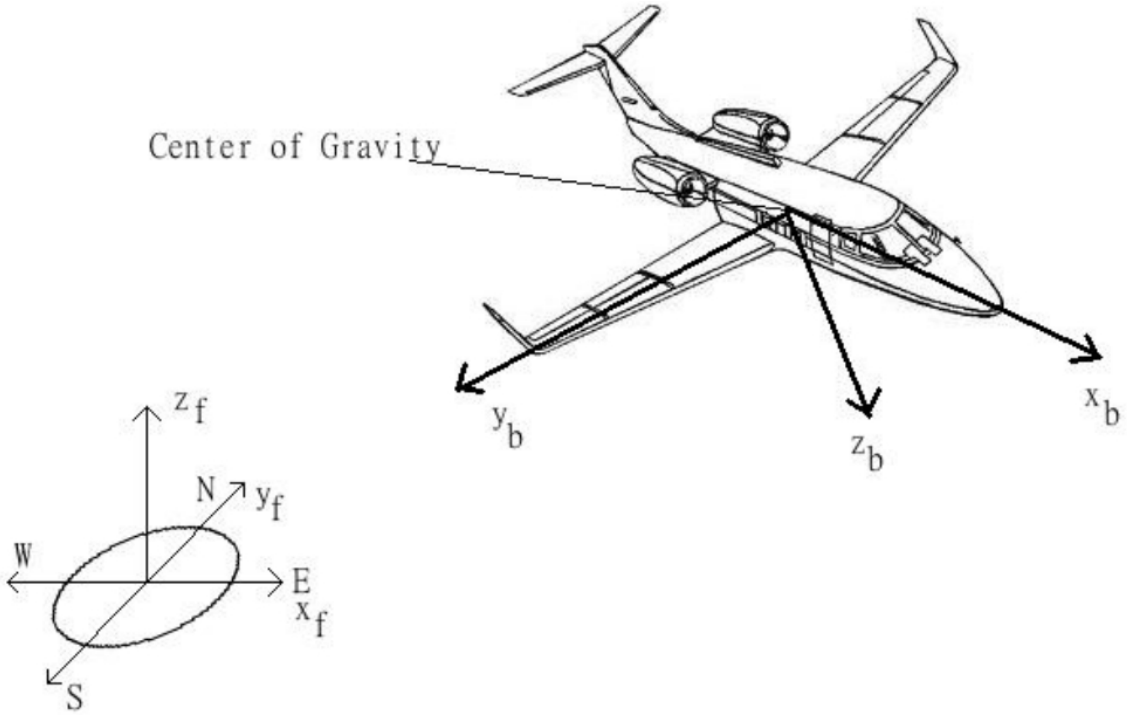

Figure 3: The body fixed and Earth fixed coordinate system

Atmosphere fixed coodinate system

- Aerodynamic forces and moments are described in terms of atmosphere fixed coordinate system.
- Denoted by (x_a, y_a, z_a), all axes are parallel to earth-fixed coordinate system.
- Atmosphere fixed coordinate system moves at a constant velocity relative to earth fixed coordinate system i.e., wind.

Body fixed coordinate system

- The inertia tensor is most conveniently described in terms of body fixed coordinate system.
- Origin is located at the aircraft center of gravity and is moving along with the aircraft.
- x_b - axis point forward along some convenient axis of the fuselage in the aircraft's plane of symmetry.
- y_b - axis is normal to the plane of symmetry and points towards the direction of right wing.

- z_b - axis points downwards in the aircraft plane of symmetry, completing the right-handed Cartesian system.

Ground Speed (V_g)**:**

Velocity of the body fixed coordinate relative to the earth fixed coordinate system.

Airspeed (V)**:**

The velocity of the body fixed coordinate system relative to the atmosphere fixed coordinate system.

Ground speed and airspeed are related as:

$$V_g = V + V_w \tag{1}$$

where,

V_w is the velocity of atmosphere relative to earth, or wind.