

Professional Certificate in Aerospace Engineering

Aerodynamics and Flight Mechanics

Aerodynamics is the study of the motion of air, and the forces and moments it exerts on solid objects, such as aircraft. Flight mechanics is the study of the motion of aircraft and the forces and moments that cause this motion. In this explanation, we will cover key terms and vocabulary related to aerodynamics and flight mechanics that are essential for the Professional Certificate in Aerospace Engineering.

Airfoil: An airfoil is a shape designed to produce lift when air flows over it. The shape of an airfoil is defined by its camber line, thickness distribution, and leading and trailing edges. The camber line is the curve that lies halfway between the upper and lower surfaces of the airfoil. The thickness distribution is the distribution of thickness from the leading edge to the trailing edge. The leading and trailing edges are the front and back of the airfoil, respectively.

Lift: Lift is the force that acts perpendicular to the direction of flow of air. It is generated by the pressure difference between the upper and lower surfaces of an airfoil. The lift coefficient (CL) is a dimensionless number used to quantify the amount of lift generated by an airfoil at a given angle of attack (AOA). The lift coefficient is defined as:

$$CL = L/qS$$

where L is the lift force, q is the dynamic pressure, and S is the reference area.

Drag: Drag is the force that acts parallel to the direction of flow of air. It is generated by the friction and pressure difference between the airfoil and the surrounding air. The drag coefficient (CD) is a dimensionless number used to quantify the amount of drag generated by an airfoil at a given AOA. The drag coefficient is defined as:

$$CD = D/qS$$

where D is the drag force.

Angle of Attack: The angle of attack (AOA) is the angle between the chord line of an airfoil and the direction of flow of air. The AOA is a critical parameter in aerodynamics as it affects the amount of lift and drag generated by an airfoil.

Moment: A moment is a force that causes rotation. In aerodynamics, moments are usually measured about the center of gravity (CG) of an aircraft. The moment coefficient (CM) is a dimensionless number used to quantify the amount of moment generated by an airfoil at a given AOA. The moment coefficient is defined as:

$$CM = M/qSc$$

where M is the moment and c is the mean aerodynamic chord.

Stall: A stall is a condition in which the lift generated by an airfoil decreases rapidly due to a separation of the flow from the upper surface of the airfoil. This occurs when the AOA is increased beyond a critical angle. A stall can result in a loss of control of an aircraft.

Pitching Moment: The pitching moment is the moment generated by the aerodynamic forces acting on an airfoil about the CG. The pitching moment can be positive or negative, depending on the direction of the moment. A positive pitching moment tends to pitch the nose up, while a negative pitching moment tends to pitch the nose down.

Thrust: Thrust is the force that propels an aircraft forward. It is generated by the engines of an aircraft. The thrust required (TR) is the amount of thrust required to maintain a constant airspeed and altitude.

Weight: Weight is the force due to gravity acting on an aircraft. It is equal to the mass of the aircraft multiplied by the acceleration due to gravity. The weight of an aircraft affects its performance, including its range, endurance, and climb rate.

Glide Ratio: The glide ratio is the ratio of the horizontal distance traveled to the vertical distance descended by an aircraft in steady, unaccelerated flight. It is a measure of the aircraft's efficiency in gliding flight.

Lift-to-Drag Ratio: The lift-to-drag ratio (L/D) is the ratio of lift to drag generated by an airfoil. It is a measure of the aerodynamic efficiency of an airfoil. A higher L/D ratio indicates a more efficient airfoil.

Center of Gravity: The center of gravity (CG) is the point about which the weight of an aircraft acts. The CG affects the stability and control of an aircraft. The CG must be within certain limits for the aircraft to be stable and controllable.

Mach Number: The Mach number is the ratio of the true airspeed of an aircraft to the speed of sound. It is a dimensionless number used to describe the compressibility effects of air on an aircraft.

Reynolds Number: The Reynolds number is a dimensionless number used to describe the flow regime of a fluid. It is calculated as the product of the density, velocity, and length scale of the fluid, divided by the viscosity of the fluid.

Supersonic: Supersonic flight is flight in which the true airspeed of an aircraft exceeds the speed of sound. Supersonic flight is characterized by shock waves and compressibility effects.

Hypersonic: Hypersonic flight is flight in which the true airspeed of an aircraft is much greater than the speed of sound. Hypersonic flight is characterized by extreme shock waves and compressibility effects.

In summary, aerodynamics and flight mechanics are critical components of aerospace engineering.

Understanding the key terms and vocabulary related to these fields is essential for success in the Professional Certificate in Aerospace Engineering. The terms and concepts covered in this explanation, including airfoil, lift, drag, angle of attack, moment, stall, pitching moment, thrust, weight, glide ratio, lift-to-drag ratio, center of gravity, Mach number, Reynolds number, supersonic, and hypersonic, are fundamental to the study and practice of aerodynamics and flight mechanics. By mastering these concepts, learners will be well-prepared to tackle the challenges and opportunities in the aerospace engineering field.