Aerospace Engineering Cheatsheet

A concise reference for key aerospace engineering concepts, equations, and definitions, useful for quick lookups and exam preparation.

Aerodynamics Fundamentals

Key Definitions

Airfoil	The cross-sectional shape of a wing designed to produce lift and minimize drag.
Angle of Attack (AoA)	The angle between the airfoil's chord line and the direction of the relative wind.
Lift	The aerodynamic force acting perpendicular to the direction of the relative wind.
Drag	The aerodynamic force acting parallel to the direction of the relative wind, opposing motion.
Stall	Condition where increasing the angle of attack decreases the lift coefficient.
Chord	The straight line connecting the leading and trailing edges of an airfoil.

Important Equations

Lift Equation	$L = \frac{1}{2} \rho V^2 S C_L$ Where: • L = Lift • ρ = Air density • V = Velocity • S = Wing area • C_L = Lift coefficient
Drag Equation	$D = \frac{1}{2} \rho V^2 S C_D$ Where: • D = Drag • ρ = Air density • V = Velocity • S = Wing area • C_D = Drag coefficient
Momentum Equation	$F = m \cdot a$ Where: • F = Force • m = Mass • a = Acceleration
Continuity Equation	$\rho_1 A_1 V_1 = \rho_2 A_2 V_2$ Where: • ρ = Density • A = Area • V = Velocity

Aerodynamic Coefficients

Aerodynamic coefficients (C_L, C_D, C_M) are dimensionless numbers that characterize the aerodynamic performance of an airfoil or aircraft. They depend on the shape of the airfoil, the angle of attack, and the Reynolds number.

A typical lift coefficient (C_L) ranges from 0.2 to 1.5. Drag coefficients (C_D) are usually much smaller, ranging from 0.01 to 0.1.

Aircraft Propulsion

Engine Types

Turbojet	An airbreathing jet engine that uses a turbine to drive a compressor. Efficient at high speeds.
Turbofan	Similar to a turbojet, but with a large fan at the front that bypasses some air around the core engine. More efficient at lower speeds.
Turboprop	A turbine engine that drives a propeller. Efficient at low speeds and altitudes.
Rocket Engine	An engine that carries its own oxidizer and fuel, allowing it to operate in a vacuum. Used for spaceflight.
Ramjet	An airbreathing jet engine that uses the aircraft's forward motion to compress incoming air. Operates at supersonic speeds.
Scramjet	A supersonic combustion ramjet engine that operates at hypersonic speeds.

Thrust Equation

The general thrust equation is given by:
$T = \dot{m} (V_e - V_0) + (p_e - p_0)A_e$

Where:

- T = Thrust
- $\dot{m}$ = Mass flow rate
- V_e = Exit velocity
- V_0 = Inlet velocity
- p_e = Exit pressure
- p_0 = Inlet pressure
- A_e = Exit area

In ideal conditions where the exit pressure equals the ambient pressure ($p_e = p_0$), the equation simplifies to:
$T = \dot{m} (V_e - V_0)$

Performance Parameters

Specific Thrust	Thrust per unit mass flow rate ($T/\dot{m}$).
Specific Fuel Consumption (SFC)	The amount of fuel consumed per unit of thrust per unit of time. Lower SFC indicates better fuel efficiency.
Thrust-to-Weight Ratio	The ratio of the engine's thrust to its weight. Higher ratios indicate better performance.

Aircraft Structures

Structural Components

Fuselage	The main body of the aircraft that houses the crew, passengers, and cargo.
Wings	Provide lift for the aircraft. Include control surfaces like ailerons and flaps.
Empennage (Tail)	The tail assembly, including the vertical and horizontal stabilizers, rudder, and elevators. Provides stability and control.
Landing Gear	Supports the aircraft on the ground during takeoff and landing.
Engine Mounts	Structural components that secure the engines to the airframe.

Stress and Strain

Stress (\sigma)	Force per unit area. \sigma = \frac{F}{A}
Strain (\epsilon)	Deformation per unit length. \epsilon = \frac{\Delta L}{L}
Young's Modulus (E)	A measure of the stiffness of a material. E = \frac{\sigma}{\epsilon}
Shear Stress (\tau)	Stress acting parallel to a surface. \tau = \frac{F}{A} (parallel)

Materials

Common materials in aircraft structures include aluminum alloys, titanium alloys, steel alloys, composites (carbon fiber, fiberglass), and specialized high-temperature alloys.
Material selection depends on strength-to-weight ratio, corrosion resistance, fatigue resistance, and cost.

Flight Mechanics

Aircraft Performance

Range	The total distance an aircraft can fly on a given amount of fuel.
Endurance	The total time an aircraft can stay airborne on a given amount of fuel.
Rate of Climb	The vertical speed of an aircraft during climb.
Ceiling	The maximum altitude an aircraft can reach.
Takeoff Distance	The distance required for an aircraft to accelerate from rest to takeoff speed.
Landing Distance	The distance required for an aircraft to decelerate from landing speed to a stop.

Aircraft Stability

Static Stability	The initial tendency of an aircraft to return to its equilibrium state after a disturbance.
Dynamic Stability	The long-term behavior of an aircraft after a disturbance. It describes how the aircraft oscillates and eventually returns to equilibrium.
Longitudinal Stability	Stability about the pitch axis.
Lateral Stability	Stability about the roll axis.
Directional Stability	Stability about the yaw axis.

Control Surfaces

Control surfaces are movable aerodynamic surfaces used to control an aircraft's attitude and direction. They include ailerons (roll), elevators (pitch), and rudder (yaw).
Flaps and slats are high-lift devices used to increase lift during takeoff and landing.