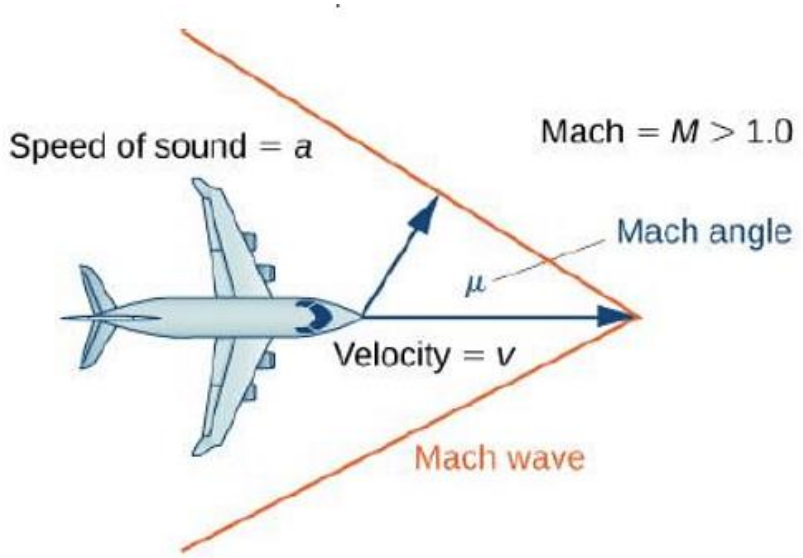
Subject Code & Name**: 23AST101 Fundamentals of Aerospace Engineering**

Topic: Mach number

The Mach number is a dimensionless quantity in fluid dynamics and aerodynamics that represents the ratio of the speed of an object moving through a fluid to the local speed of sound in that fluid. It is named after the Austrian physicist Ernst Mach.



Definition and Calculation

Mach number (M)= V/A

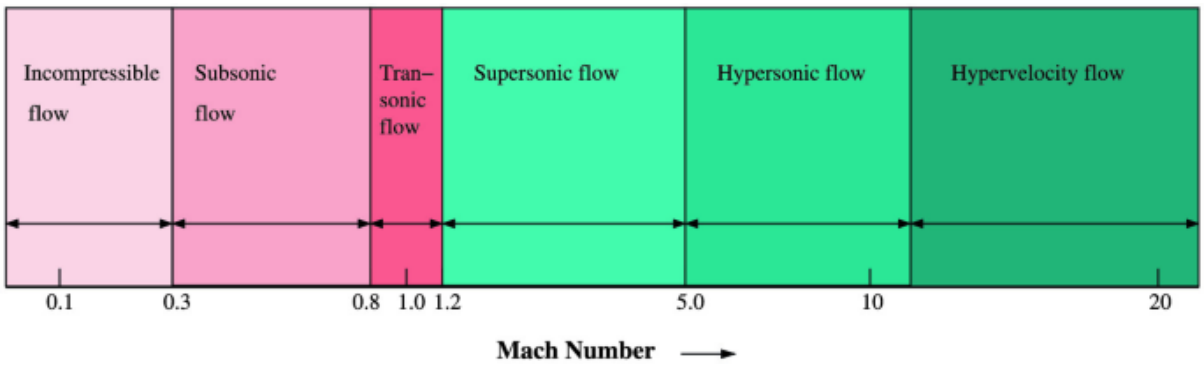
Where:

- v is the speed of the object relative to the fluid.
- a is the local speed of sound in the fluid.

Speed of Sound

The speed of sound, a, varies with the medium and its properties, particularly temperature. In air at sea level and at 15°C, the speed of sound is approximately 343 meters per second (1,235 kilometers per hour or 767 miles per hour).

Mach number Regimes



The Mach number is used to classify the speed regimes of flight and fluid flow:

1. **Subsonic (M < 1):**
    - The object's speed is less than the speed of sound. Typical for most commercial airplanes and low-speed flows.
2. **Transonic (M ≈ 1):**
    - Speeds close to the speed of sound. In this regime, both subsonic and supersonic flows exist around the object, leading to complex aerodynamics. This typically occurs between Mach 0.8 and 1.2.
3. **Supersonic (1 < M < 5):**
    - The object's speed exceeds the speed of sound. Shock waves form, and flow characteristics change significantly. Many military aircraft and some research vehicles operate in this regime.
4. **Hypersonic (M > 5):**
    - Speeds much greater than the speed of sound. Aerodynamic heating becomes a significant challenge, and specialized materials and designs are required. Spacecraft re-entry vehicles and experimental aircraft often reach these speeds.

Practical Applications

- **Aerospace Engineering:** The Mach number is critical in designing aircraft and spacecraft, as it affects aerodynamic forces, pressure distributions, and thermal loads.
- **Fluid Dynamics:** Understanding the Mach number helps in analyzing the behavior of gases in various flow conditions, such as in nozzles, diffusers, and around objects.
- **Weather and Atmospheric Science:** The Mach number concept is used to study atmospheric phenomena involving high-speed winds and shock waves.

Examples of Mach Numbers

- **Commercial Jet Airliners:** Typically cruise at Mach 0.8 to 0.85 (subsonic).
- **Concorde (Supersonic Transport):** Cruised at about Mach 2.04.
- **SR-71 Blackbird (Reconnaissance Aircraft):** Could fly at speeds over Mach 3.
- **Space Shuttle during Re-entry:** Exceeds Mach 25.

Understanding the Mach number is essential for designing efficient and safe aircraft, understanding fluid flow, and exploring high-speed travel technologies.