Lecture 2: Common flow variables

Saturday, September 5, 2020 8:44 PM

LAST TIME: How we study AERODYNAMICS

Forces + balance

Look-up

u, P, ρ, T

Typical variables

TODAY: Common FLOW VARIABLES (u, P, T, ρ, μ)

- what they mean
- how they generate FORCE

B. Common VARIABLES in AERODYNAMICS

molecular

u	P	μ	ρ	T
Velocity	Pressure	viscosity	density	temperature

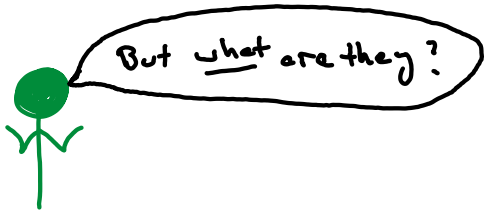
Assumption:

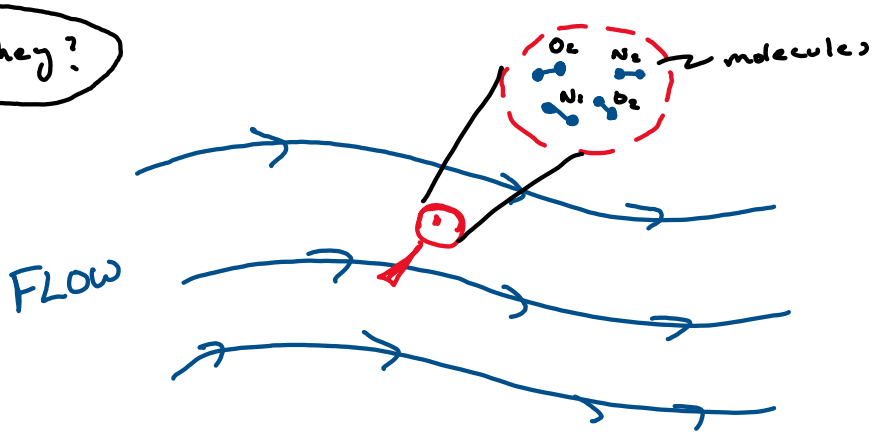
Incompressible & Inviscid
$\rho = const.$ $\mu = 0$

Incompressible, viscous
$\rho = const.$ $\mu \neq 0$

Compressible, viscous
$\rho = f(x, y, z, t)$ $\mu \neq 0$

All these dictate the FORCE on an OBJECT due to FLOW



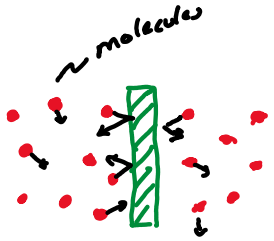


(1) VELOCITY u, v, w UNITS: m/s

↳ How fast an infinitesmally small FLUID ELEMENT passes through our OBSERVATION WINDOW (EULERIAN P.O.V.)

↳ NOT a molecular quantity, satisfies CONTINUUM ASSUMPTION

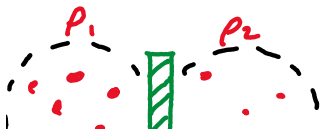
(2) PRESSURE P UNITS: $\frac{N}{m^2}$ or Pa



↳ FORCE on a surface from FLUID molecule bashing into it.

↳ If there's a PRESSURE DIFFERENCE (ΔP) across the surface, a NET FORCE is produced.

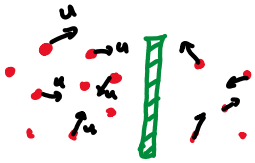
(3.) DENSITY ρ UNITS: kg/m^3



↳ How heavy a FLUID is "per unit volume" m/V

(i.e., how many molecules stuffed in a volume) ← volume

(4.) TEMPERATURE T UNITS: K



$T \sim KE \sim u^2$

↳ How much KINETIC ENERGY each MOLECULE has

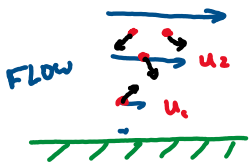
↳ Based on MOLECULAR VELOCITY, not FLUID VELOCITY

NOTE: P, ρ, T can all produce FORCES on an OBJECT through their relation in the "IDEAL GAS LAW"

$$P = R \rho T$$

(R: const.)

(5.) VISCOSITY μ UNITS: $Pa \cdot s$ or $\frac{N s}{m^2}$



↳ Coefficient that represents FLUID FRICTION

↳ · In a FLOW as MOLECULES jump streamlines they change velocity $u_2 \rightarrow u_1$

· Change in velocity results in FORCE $(F = ma = m\frac{du}{dt})$

· This force is VISCOUS FORCE

NOTE: requires a FLOW GRADIENT!