Homework #2

Due: November 2 (Tuesday), 2021

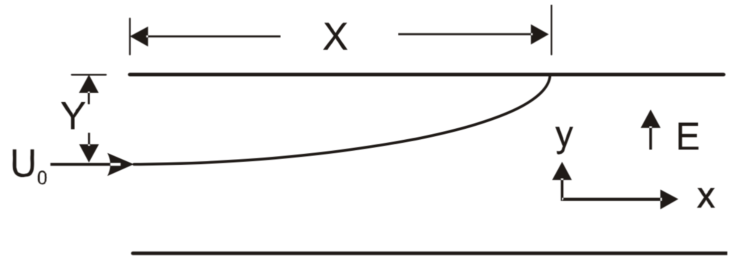
*You may submit your homework to TA (chl_ghdtjr@naver.com) by email or submit to 313-222.

1. A spherical droplet is rotating with an angular velocity ω_i as it moves with a translational velocity of U_i at its center of mass. Assume that the droplet is evaporating uniformly. Is the expression of $mdU_i/dt = F_i$, where F_i is the force acting on the particle, still applicable? Determine by applying the Reynolds transport theorem to the rotating, evaporating droplet.

2. A droplet is injected with a velocity v_o into a quiescent medium (no motion). The droplet evaporates according to the D^2-law and Stokes drag is applicable. The drag force is the only force acting on the droplet (no gravity) and the mass flux is uniform over the surface.

- Derive an equation for the droplet velocity and distance as a function of v_o, t and τ_V/τ_m. The definitions of the time constant is the same as we dealt in the class.
- Setting $t = \tau_m$, evaluate the distance traveled for $\tau_V/\tau_m \ll 1.0$ and $\tau_V/\tau_m \gg 1.0$.

3. A charged particle is injected into a channel with quiescent fluid and a uniform electric field strength. The initial velocity of the particle is U_o and the distance from the injection point to the wall (collecting surface) is *L*. Find the axial distance the particle will travel before it impacts the wall in terms of electric field strength, E, the aerodynamic response time of the particle, the charge to mass ratio on the particle (q/m), the initial velocity and the distance to the wall. Neglect gravitational effects.



4. Consider a flow of evaporating particles in a one-dimensional (x-direction) duct. The particles evaporate according to the D^2-law and are always in kinetic equilibrium with the gas. The number flow rate $\dot{n}$ of the particles is constant so $\dot{n} = n\tilde{v}A = n\langle u\rangle A = const$, where *n* is the particle number density. The particle volume fraction is sufficiently small that the continuous phase volume fraction can be taken as unity, $\alpha_c \simeq 1.0$.

- Find an expression for the mass source term in the form of $S_m = -n\dot{m} = f(Z_o, \frac{\langle u\rangle_o}{\langle u\rangle}, \rho_c, \tau_m, \frac{D}{D_o})$, where Z_o, $\langle u\rangle_o$, and D_o are the loading, velocity and particle diameter at the beginning station in the tube. The evaporation time constant is τ_m and ρ_c is the gas density.

- Using the continuous phase continuity equation, $\frac{\Delta}{\Delta x}(\rho_c\langle u\rangle) = S_m$, find how the velocity varies with time in the form of $\frac{\langle u\rangle}{\langle u\rangle_o} = f(Z_o, \frac{t}{\tau_m})$ and find the velocity ratio when evaporation is complete. When you complete the expression for S_m you will find a velocity $\langle u\rangle$ in the denominator which when combined with the continuity equation allows you to express $\langle u\rangle\frac{\Delta}{\Delta x}(\rho_c\langle u\rangle) = \rho_c\frac{\Delta\langle u\rangle}{\Delta t}$.