Homework 7

① H = 11 m   d = 2.5 m   Q = 7 g/s   u = 2 m/s

V = 0.3 m/s T_s = 100°C T_a = 25°C

$$F_b = g \frac{d^2 V}{4}\left(\frac{T_s - T_a}{T_s}\right) = (10)\frac{(2.5)^2(0.3)}{4}\left(\frac{373-298}{373}\right)$$

$$= 0.9425$$

$$\Delta H = \frac{1.6\, F_b^{1/3} x^{2/3}}{u} = \frac{1.6\,(0.9425)^{1/3} x^{2/3}}{2} = 0.78\, x^{2/3}$$

$$H = 11 + 0.78\, x^{2/3} = 11 + 0.78\,(1400)^{2/3} = 108.6\ \text{m}$$

Sunny ; 2 m/s ⇒ Case A

From table
$$\begin{cases} \sigma_y = 300\ \text{m} \\ \sigma_z = 1000\ \text{m} \end{cases}$$

$$C = \frac{Q}{2\pi u \sigma_z \sigma_z} e^{-y^2/\sigma_y^2}\left[e^{-\frac{(z-H)^2}{\sigma_z^2}} + e^{-\frac{(z+H)^2}{\sigma_z^2}}\right]$$

y=0, z=0 ⇒ $C(z=0) = 3.~~77~~ \times 10^{-6}$ g/m³

y=0, z=8 ⇒ $C(z=8) = 3.7 \times 10^{-6}$ g/m³

(2) $M = 20\ kg$ $H = 12\ m$

$x = 750\ m$ $u = 3\ m/s$

$y = 0,\ z = 0$

$$C = \frac{M}{(2\pi)^{3/2}\sigma_x\sigma_y\sigma_z} e^{-\frac{(x-ut)^2}{\sigma_x^2}} e^{-y^2/\sigma_y^2}\left[e^{-\frac{(z-H)^2}{\sigma_z^2}} + e^{-\frac{(z+H)^2}{\sigma_z^2}}\right]$$

Stable $\sigma_x = \sigma_y = 8\ m$, $\sigma_z = 2.5\ m$ } From tables

Max at $t = x/u$

$$\Rightarrow C_{stable} \Rightarrow C = \frac{20}{(2\pi)^{3/2}(8)^2(2.5)} e^0 e^0 2\left[e^{-\frac{20^2}{2.5^2}}\right]$$

$$= 2.5 \times 10^{-30}\ kg/m^3$$

Unstable $\sigma_x = \sigma_y = 75\ m$, $\sigma_z = 70\ m$ } From table

$$C = \frac{20}{(2\pi)^{3/2}(75)^2(70)} e^0 e^0 2\left[e^{-\frac{20^2}{70^2}}\right]$$

$$= 6 \times 10^{-6}\ kg/m^3$$

(3) $v_{settle} = \dfrac{2 r^2 g (\rho_s - \rho_f)}{9 \mu}$

$Q_f = v_f A$
$= 25 v_f$

$= \dfrac{2 r^2 (10)(2000 - 1)}{9 (2 \times 10^{-5})} = 2.2 \times 10^8 r^2$

$v_f (0.1 \mu m) = 2.2 \times 10^8 (10^{-7})^2 = 2.2 \times 10^{-6} m/s \Rightarrow Q_f = 5.5 \times 10^{-5} m^3/s$

$v_f (1 \mu m) = 2.2 \times 10^8 (10^{-6})^2 = 2.2 \times 10^{-4} m/s \Rightarrow Q_f = 5.5 \times 10^{-3} m^3/s$

$v_f (10 \mu m) = 2.2 \times 10^8 (10^{-5})^2 = 2.2 \times 10^{-2} m/s \Rightarrow Q_f = 5.5 \times 10^{-1} m^3/s$

$v_f (100 \mu m) = 2.2 \times 10^8 (10^{-4})^2 = 2.2 m/s \Rightarrow Q_f = 55 \times 10^{-3} m^3/s$

I assume size is radius

~~[illegible] $\frac{Q_f}{Q_{in}}$ [illegible]~~

$Q_{in} = \dfrac{3 \times (5 \times 5 \times 4)}{3600} = 0.083 m^3/s$

$\Rightarrow \alpha (0.1 \mu m) = \dfrac{Q_f}{Q_{in}} = 6.6 \times 10^{-4}$

$\alpha (1 \mu m) = 6.6 \times 10^{-2}$

$\alpha (10 \mu m) = 6.6$

$\alpha (100 \mu m) = 660$

Now for $K_{in} = 1$ $K_s = 0$

	0.1 μm	1 μm	10 μm	100 μm
$K_W = \frac{1}{1+\alpha}$	0.999	0.94	0.015	0.00151
$K_e = \frac{1+\alpha}{(\alpha+1)^2-\alpha}$	0.999	0.99	0.0151	0.00151
$K_M = \frac{1}{(\alpha+1)^2-\alpha}$	0.999	0.93	0.00022	2.3×10^{-6}
$\bar{K} = \zeta K_e + (1-\zeta) K_M$	0.999	0.965	0.0077	7.6×10^{-4}

$\zeta = 2/4 = 1/2$

g/m³

For $K_{in} = 0$ $K_s = 1$

$K_W = \frac{1}{1+\alpha}$	0.999	0.94	0.13	0.00151
$K_e = \frac{\alpha}{(\alpha+1)^2-\alpha}$	6.6×10^{-5}	0.062	0.13	0.00151
$K_M = \frac{1+\alpha}{(\alpha+1)^2-\alpha}$	0.999	0.996	0.15	0.00151
$\bar{K}_v = \frac{1}{2} K_e + \frac{1}{2} K_M$	0.5	0.53	0.14	0.00151