Today, we will:

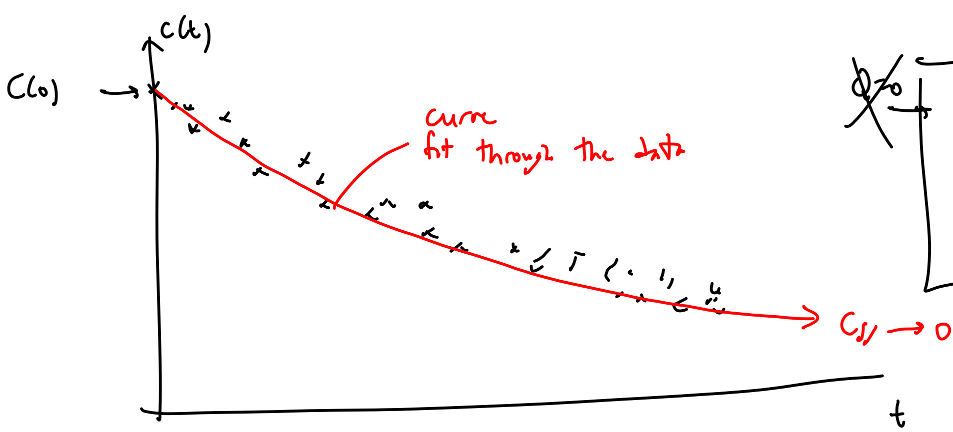
- Discuss **Wall Losses** in **Section 5.5**
- Discuss how to measure the wall loss coefficient
- Discuss **Recirculation** in **Section 5.6**
- Do some example problems

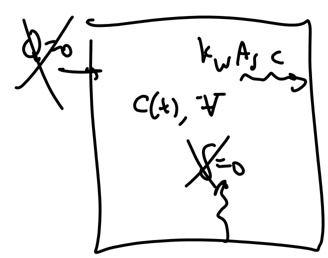
Recall, wall loss term (a sink of contaminant mass):

$$\boxed{\dot{m}_{\text{wall loss}} = k_w A_s c}$$

How to measure wall loss coefficient ??

- Put a large concentration of contaminant (S = big) in a room of vol. $\forall$
- At some time (call it $t=0$), turn source off $S=0$
- Also, seal the room, so that $Q=0$ [no infiltration or supply air]
- Measure $c(t)$ in the room





Analysis: For constant coefficients, we have

$$(1) \rightarrow \boxed{\frac{c_{ss} - c}{c_{ss} - c(0)} = \exp(-At)}$$

$$c_{ss} = \frac{B}{A} = \frac{\cancel{S} + \cancel{Q}c_a}{\cancel{Q} + k_w A_s} = 0$$

$$A = \frac{\cancel{Q} + k_w A_s}{\forall} = \frac{k_w A_s}{\forall}$$

Eq. (1) becomes

$$\boxed{C = C(0)\exp\left[\frac{-k_w A_s}{\forall} t\right]} \quad (2)$$

$[\log(ab) = \log a + \log b]$

Take $\log_{10}$ of both sides

$$\log_{10}(C) = \log_{10}[C(0)] + \log\left\{\exp\left[\frac{-k_w A_s}{\forall} t\right]\right\}$$

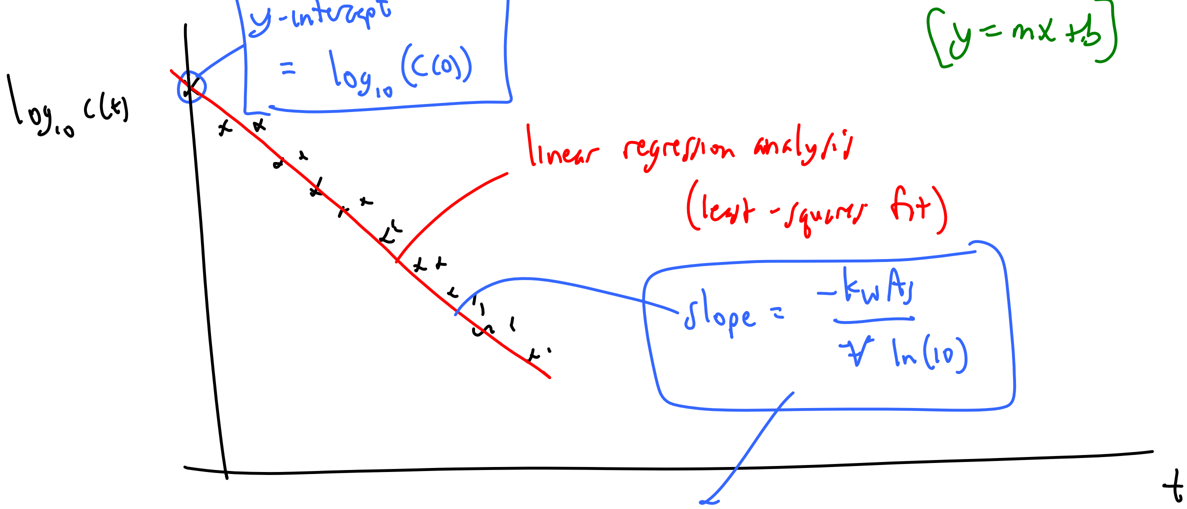
$$\log_{10}(C) = \log_{10}[C(0)] - \frac{\frac{k_w A_s}{\forall} t}{\ln(10)}$$

$\ln(10) \simeq 2.302$

$$\boxed{\log_{10}(x) = \frac{\ln(x)}{\ln(10)}}$$

Let's plot $\log_{10}(C)$ vs t

Eq is in standard form for a straight line $[y = mx + b]$



$\therefore$ Solve for k_w

Wall desorption:

adsorption $\rightarrow$ $\boxed{\dot{m}_{\text{wall loss}} = k_w A_s C}$ is for adsorption into the surface

It is always a sink of mass

desorption $\rightarrow$ Many eq's in the literature:

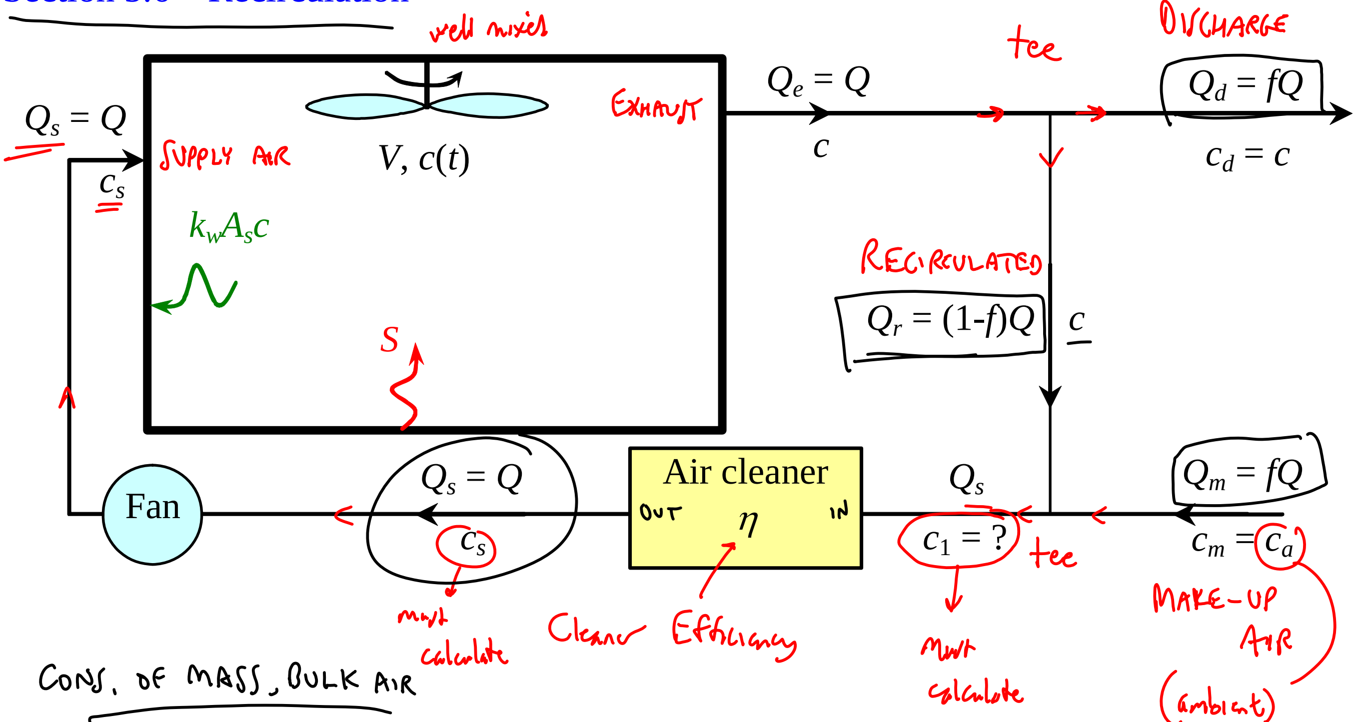
one is $\boxed{\dot{m}_{\text{wall loss}} = k_w A_s (C - C_d)}$

if $C > C_d$, adsorption

if $C < C_d$ desorption

"wall loss" becomes a source

Section 5.6 – Recirculation



CONS. OF MASS, BULK AIR

- $\boxed{Q_s = Q_e = Q}$ (Bulk air)

  supply exhaust

- $\boxed{Q_d = Q_m}$

  discharge make-up

- bottom tee → $\boxed{Q_s = Q_r + Q_m}$
- top tee → $\boxed{Q_e = Q_r + Q_d}$

Cons. of mass of the bulk air (volume flow rates).

$Q_m = Q_d$ ✓

- Define f = make-up air fraction $\boxed{f \equiv \dfrac{Q_m}{Q}}$ → $Q_m = fQ$

$$Q_r = Q_s - Q_m$$
$$= Q - fQ$$
$$= (1-f)Q$$

$\boxed{Q_r = (1-f)\,Q}$ $\quad$ $\boxed{Q_d = Q_m = fQ}$

Note: $f=1$ means no recirculated air → "100% make-up air"

$f=0$ means 100% recirculated air → "no make-up air"

[Infiltration in a typical home is $\simeq 1 \frac{\text{air exchange}}{\text{hr}}$]

See Table 5.4

We never have $f=0$, since there is always some infiltration in any real building

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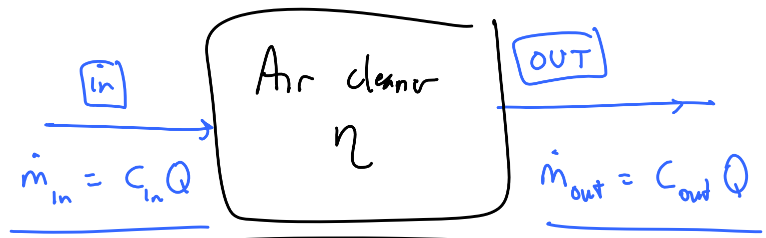
Air cleaner efficiency



Define $\boxed{\eta = \frac{\text{rate of pollutant mass removed}}{\text{" " " " entering}}}$

i.e. ☆ $\boxed{\eta = \frac{\dot m_{in} - \dot m_{out}}{\dot m_{in}}} = 1 - \frac{\dot m_{out}}{\dot m_{in}} = 1 - \frac{C_{out}\cancel{Q}}{C_{in}\cancel{Q}} = 1 - \frac{C_{out}}{C_{in}}$

$$\therefore \boxed{C_{out} = (1-\eta)\, C_{in}} \quad ☆$$

Here, in our room,

$$\eta = \frac{\dot m_{in} - \dot m_{out}}{\dot m_{in}} = \frac{(Q_r c + Q_m c_a) - Q_s c_s}{Q_r c + Q_m c_a}$$

or $\boxed{\eta = 1 - \frac{Q_s c_s}{Q_r c + Q_m c_a}}$

But, $Q_s = Q$

$Q_r = (1-f)Q$

$Q_m = fQ$

So, $$\eta = 1 - \frac{c_s}{(1-f)c + f c_a}$$

So, $$\boxed{c_s = (1-\eta)\left[f c_a + c(1-f)\right]} \quad ★ \qquad (3)$$

Cons. of mass eq. for the contaminant: (we have dropped the j subscript)

$$\boxed{\forall \frac{dc}{dt} = Q c_s + S - Qc - k_w A_s c} \qquad (4)$$

Plug (3) into (4)

★ Notice: C_s has a component containing c

" " " " " " — that does not contain c

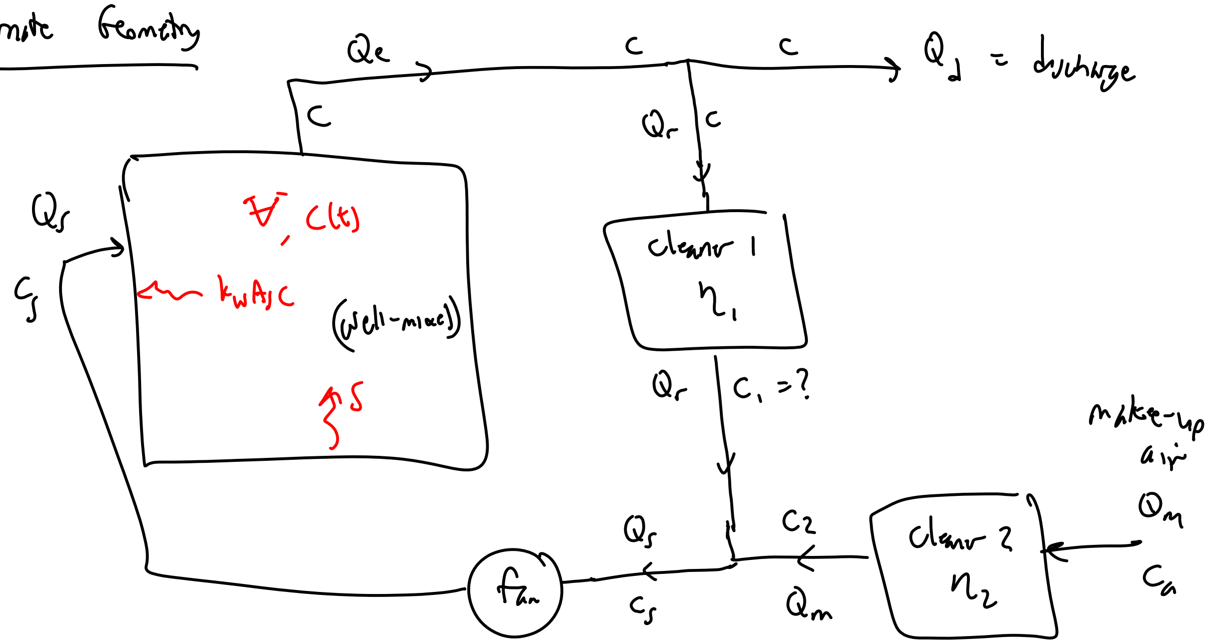
$$\frac{dc}{dt} = \underbrace{\frac{1}{\forall}\left[Q(1-\eta) f c_a + S\right]}_{=B} - \underbrace{\frac{1}{\forall}\left[Q + k_w A_s - Q(1-\eta)(1-f)\right]}_{=A} c$$

$$\boxed{\frac{dc}{dt} = B - Ac}$$

! → WE CAN SOLVE !!

For other geometries, we do a similar analysis.

Alternate Geometry



Go through a similar analysis

e.g.

$$\boxed{\begin{aligned} C_1 &= C(1-\eta_1) \\ C_2 &= C_a(1-\eta_2) \end{aligned}}$$

$$\boxed{\frac{dc}{dt} = \underbrace{\frac{S + Q_s C_a (1-\eta_2) f}{\forall}}_{B} - \underbrace{\frac{Q_s + A_s k_w - Q_s(1-\eta_1)(1-f)}{\forall}}_{A}\, C}$$

$$\frac{dc}{dt} = B - Ac$$

☆ WORK THE ALGEBRA OUT ON YOUR OWN