Today, we will:

- Continue to discuss **Wall Losses** [Section 5.5]
- Discuss how to **measure** the wall loss coefficient
- Discuss **Recirculation** [Section 5.6]

\[ \dot{m}_{\text{wall low}} = k_w A_w c \]  

**How to measure** \( k_w \)?

Recall:

\[ \dot{m}_{\text{wall low}} = k_w A_w c \]  

- Put in some initial concentration \( (S = \text{big}) \rightarrow c = c(0) \) at \( t = 0 \)
- At \( t = 0 \), turn off to remove \( S \) \( (S = 0) \)
- Also at \( t = 0 \), turn off all ventilation \( (Q = 0) \) and seal up room

- Measure \( c \) vs \( t \)

\( k_w \) from **1st or 2nd order behavior**

\[ k_w = \text{constant} \]
Analysis

Our solution is given by the following differential equation:

\[ \frac{c_{ij} - c}{c_{ij} - c(0)} = \exp\left(-A t\right) \]  

(1)

Where:

- \( c_{ij} = \frac{B}{A} \)  
- \( c_{ij} = \frac{S + QCa}{Q + kw As} \)  
- \( A = \frac{Q + kw As}{\nu} \)

\[ A = \frac{kw As}{\nu} \]

(2)

C = c(0) \exp\left(-\frac{kw As}{\nu} t\right)

(3)

We note that:

- \( \log(ab) = \log a + \log b \)
- \( \ln e = a \)
- \( \log_{10}(x) = \frac{\ln(x)}{\ln(10)} \)
Take \( \log_{10} \) of both sides of \( (2) \)

\[
\log_{10} (c) = \log_{10} (c(0)) + \log_{10} \left[ \exp \left( \frac{-kwAs}{A} \frac{t}{\ln(10)} \right) \right]
\]

\[
\log_{10} (c) = \log_{10} (c(0)) - \frac{kwAs}{A} \frac{t}{\ln(10)}
\]

"m" = slope

Eq for straight line if plot \( \log_{10} (c) \) vs \( t \)

\[
y = mx + b
\]

Here "y" = \( \log_{10} (c) \)

"x" = \( t \)

Plot \( \log_{10} (c) \) vs \( t \) to get the slope of line

best fit straight line (Regression Analysis)

\[
\text{Slope} = \frac{-kwAs}{\frac{A}{\ln(10)}}
\]

Solve for \( kw \) from this eq.
\[ \dot{m}_{\text{wall loss}} = k_w A_s C \]  

is for adsorption only  

(a sink of species mass)

As a list of species \( j \) goes into the surface, it can also start desorbing.

New eq:

One eq. is:

\[ \dot{m}_{\text{wall loss}} = k_w A_s (c-c_d) \]

If \( c > c_d \), \( \dot{m}_{\text{wall loss}} = \text{adsorption} \) \( \ast \)

If \( c < c_d \), \( \dot{m}_{\text{wall loss}} = \text{desorption} \) \( \circ \)
Recirculation [Section 5.6]

\[ Q_s = Q \]

\[ Q_e = Q \]

\[ Q_d = fQ \]

\[ c_d = c \]

\[ Q_r = (1-f)Q \]

\[ c_m = c_a \]

Air cleaner \( \eta \) or \( E \)

\[ Q_m = fQ \]

\[ Q_m \text{ must } = Q_d \]

\[ Q_r = (1-f)Q \]

\[ f = \frac{Q_m}{Q} \]

\[ Q_r = Q_s - Q_m \]

\[ = Q - fQ \]

\[ = (1-f)Q \]
Note: if $f = 1$ — no recirculation — "100% make-up air"

if $f \neq 0$ — 100% recirculated air (no make-up air)

Real rooms/buildings, $f \neq 0$

- **Infiltration** — outside air leaks in through cracks, windows, doors, etc.

- **Exfiltration** — inside air escapes out through cracks...

Typical home has $N \approx 1$ (air exchange rate)

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Air cleaner efficiency $\eta$

Air entering $C_{in}$

Air exiting $C_{out}$

\[
\eta = \frac{C_{out}}{C_{in}}
\]

Species $i$:

\[
\dot{m}_{in} = C_{in} Q
\]

\[
\dot{m}_{out} = C_{out} Q
\]

\[
\eta = \frac{\dot{m}_{in} - \dot{m}_{out}}{\dot{m}_{in}} = 1 - \frac{\dot{m}_{out}}{\dot{m}_{in}} = 1 - \frac{C_{out} Q}{C_{in} Q} = 1 - \frac{C_{out}}{C_{in}} = \eta
\]
or, \[ C_{\text{out}} = (1-n)C_{\text{in}} \]

**Goal:** Solve for \( C_s \)

**Lower "tee"**

\[ C (1-f)Q = C_s Q \]

\[ C Q_r + C_m Q_m = C_s Q_s \]

\[ C (1-f)Q + C_a fQ = C_i Q \]

\[ C_i = C (1-f) + C_a f \]

\[ C_s = (1-n)C_i = (1-n) \left[ C (1-f) + C_a f \right] \]
Finally put all this into the room eq. in standard form:

\[
\frac{dc}{dt} = B - Ac
\]

\[
\frac{dA}{dt} = Qc_s + S - Qc - kw_A c
\]

Plus in Cs:

Split up all terms with a c

\[
\text{all terms } \text{Wo a c}
\]

\[
\text{Integer algebra - do it on your own for practice!}
\]

Final Eq:

\[
\frac{dc}{dt} = \frac{1}{A} \left[ Q(1-n) + c_A + S \right] - \frac{1}{A} \left[ Q + kw_A - Q(1-n)(1-t) \right] c
\]

\[
\frac{dc}{dt} = B - Ac
\]

From here on, you know how to solve since in standard form.