Today, we will:

- Continue our discussion of **Unsteady Dilution Ventilation** in **Section 5.4**
- Do several example problems – unsteady dilution ventilation
- Discuss **Removal by Solid Surfaces (Adsorption)** in **Section 5.5**
- Discuss how to measure the wall loss coefficient
- Do Candy Questions for Candy Friday

Recall, our ventilation equation:

$$\boxed{\frac{dc}{dt} = B(t) - A(t)c}$$

See App. A-12 explains R-K

In general, use Runge-Kutta (R-K) or some other numerical scheme to solve

MATHCAD:

The derivative $\frac{dc}{dt} = \boxed{D(t,c) = B(t) - A(t)c}$

- pick a start & stop time & number of steps to use
- March in time

derivative $\frac{dc}{dt}$

$$\text{Output} = \text{Rkadapt}(c, t_{start}, t_{end}, \text{nsteps}, D)$$

Output =

row / Column	0 (time)	1 (c)
0	0	$c(0)$
1	Δt	$c(\Delta t)$
2	$2\Delta t$	$c(2\Delta t)$
3	⋮	⋮
4		
⋮		
nsteps	t_{end}	$c(t_{end})$

Example (Example 5.5 in text – the Clever Outdoorsman)

Given: A man sleeps overnight in a cabin with volume $V = 32.65\ \text{m}^3$. The rate of "fresh" air entering the cabin is 0.30 air changes per hour. The concentration of CO in the outside "fresh" air is c_a = 10 PPM (11.4 mg/m^3). A kerosene space heater emits CO according to $S(t)=1500[1+\sin(0.80\pi t)]$ mg CO per hour, where t is in hours.

To do: Calculate the concentration of CO in the cabin as a function of time.

& plot

Solution:

$$Q = \frac{Q}{\forall}\forall = N\forall = \left(0.3\ \frac{\cancel{\text{room}}}{\text{hr}}\right)\left(\frac{32.65\ \text{m}^3}{\cancel{\text{room}}}\right) = 9.795\ \text{m}^3/\text{hr}$$

$\frac{Q}{\forall}$ " N

@ $t=0$ $\quad c(0) = c_a$ [heater not on yet]

$$= 11.4\ \text{mg/m}^3$$

Solve using Mathcad [file available on website]

Bottom Line → $c \approx 150\ \text{mg/m}^3$ & oscillates

$$y_{co} \approx 130\ \text{PPM}$$

He will have a headache, but not die.

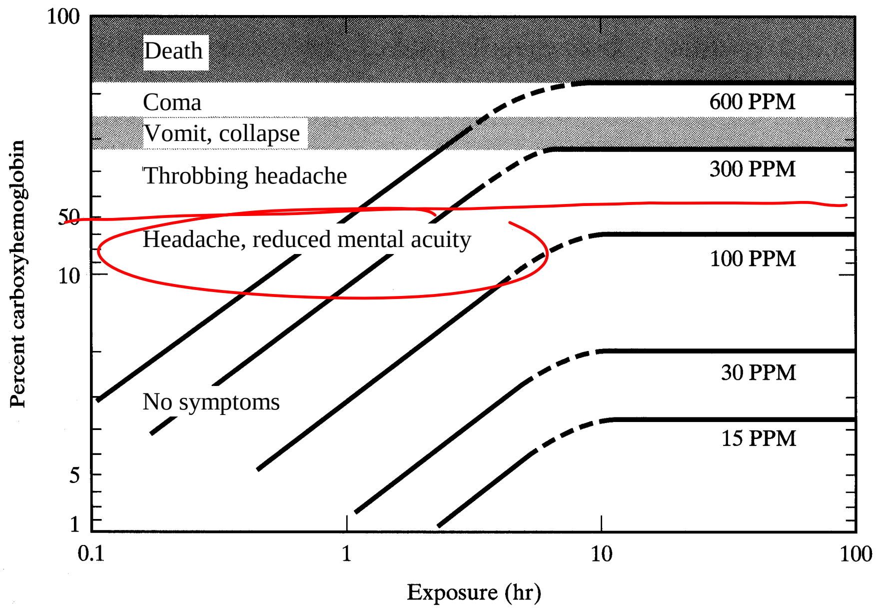


Figure 2.41 Response to carbon monoxide as a function of concentration (PPM) and exposure time (hr). The OSHA 8-hr PEL is 35 PPM and the EPA Primary Air Quality Standard is 9 PPM (redrawn from Seinfeld, 1986).

Example (Example 5.6 in text – Renovated Conference Room)

Given: The ventilation rate in a conference room (volume V = 33.3 m^3) is unsteady. The rate of emission of a hydrocarbon (HC) is also unsteady. Both Q and S are measured every half hour for 9 hours, and the data are tabulated (see text). The concentration of HC in the make-up "fresh" air is $c_a = \cancel{10}\ 5$ mg/m^3.

To do: Calculate and plot the mass concentration of HC in the room as a function of time. Also calculate its peak value and when it occurs.

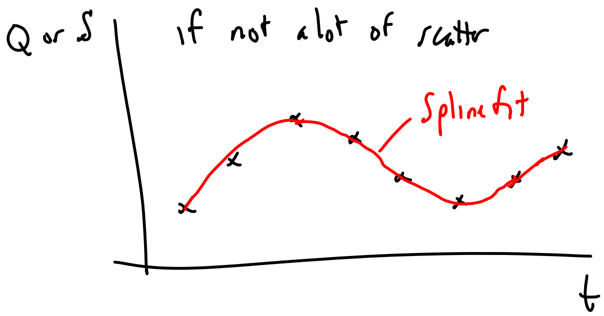
Solution:

$Q = Q(t)$, $S = S(t)$, $c_a = \text{const}$

But we don't have functions for Q & S, we have tabulated data

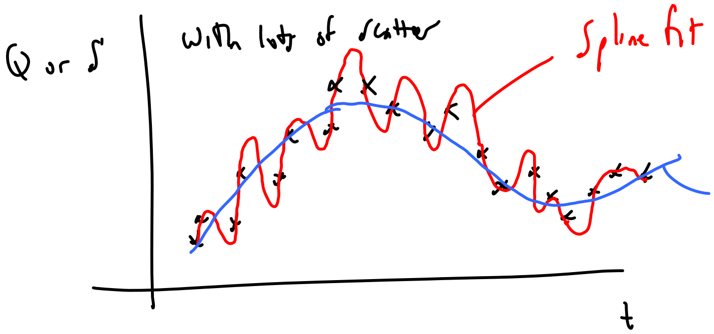
In order to use R-K, we need $Q(t)$ & $S(t)$ as functions (equations)

So – use a curve fit
- Spline fits
- least-squares fits, etc.



Spline fit goes through every data point

Spline fit is good



Spline fit not desirable here

4th-order least-squares polynomial fit does not go through each data pt.

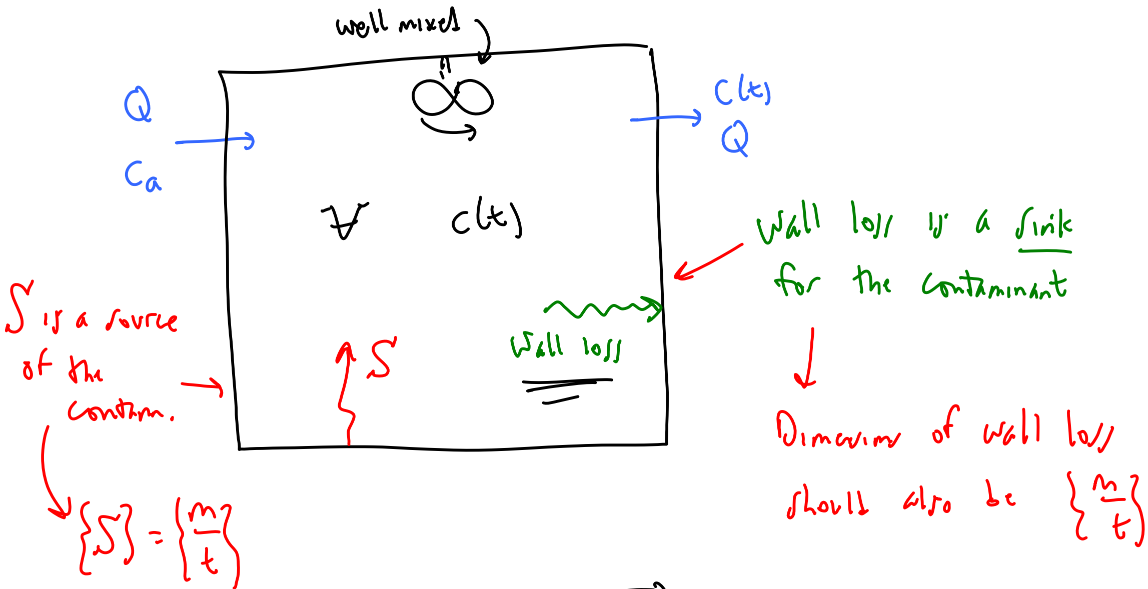
We used a spline fit in this problem

See Mathcad sol'n on website.

$\boxed{\text{Sec 5.5}}$ → Removal by solid surfaces

- Walls, furniture, curtains, etc. <u>adsorb</u> contaminants
  [& slowly desorb those contaminants]

- Terminology for this is "plate out" or "wall loss"



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

C — mass conc.

A_s — Adsorbing surface area

k_w — * <u>Wall loss coefficient</u> → Units of $\frac{m}{s}$
or deposition velocity — dims of $\left\{\frac{L}{t}\right\}$
or adsorption coeff.

See text for <u>empirical eq's</u> for k_w
- vapors
- particles

Cons. of mass of contaminant [recall, we dropped j subscript]

$$\boxed{\forall \frac{dc}{dt} = QC_a + S - QC - k_w A_s C} \quad (1)$$

To solve → Put it in standard form: $\frac{dc}{dt} = B - At$

$$\frac{dc}{dt} = \underbrace{\frac{S + Qc_a}{\forall}}_{= B} - \underbrace{\left(\frac{Q + k_w A_s}{\forall}\right)}_{= A} c$$

From here on, solution is same as previously

- If A & B are constant, can solve analytically
- If A and/or B are not constant, must usually solve numerically [e.g., use R-K] as previously