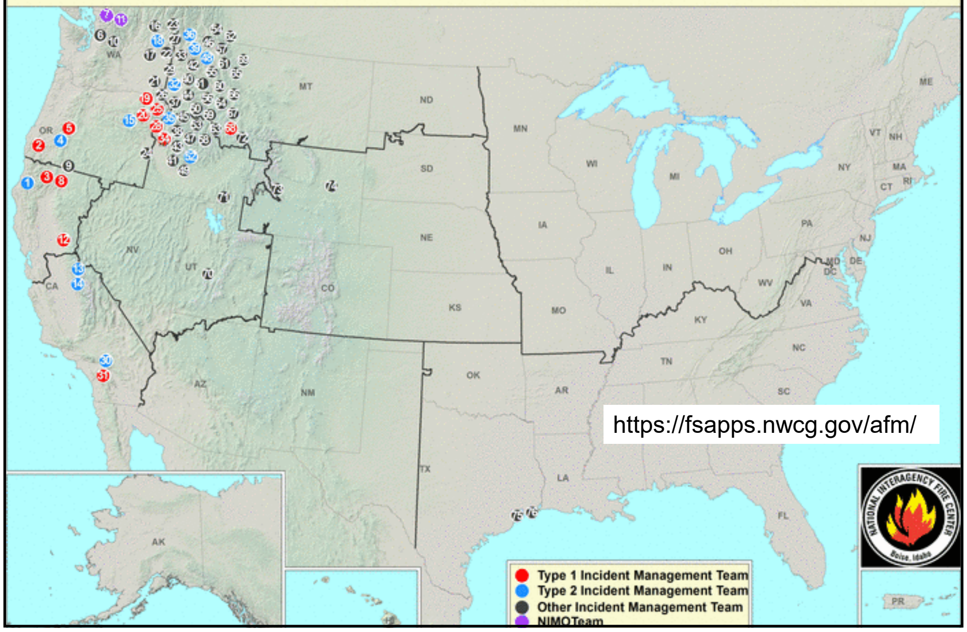
Current Large Incidents
September 09, 2022



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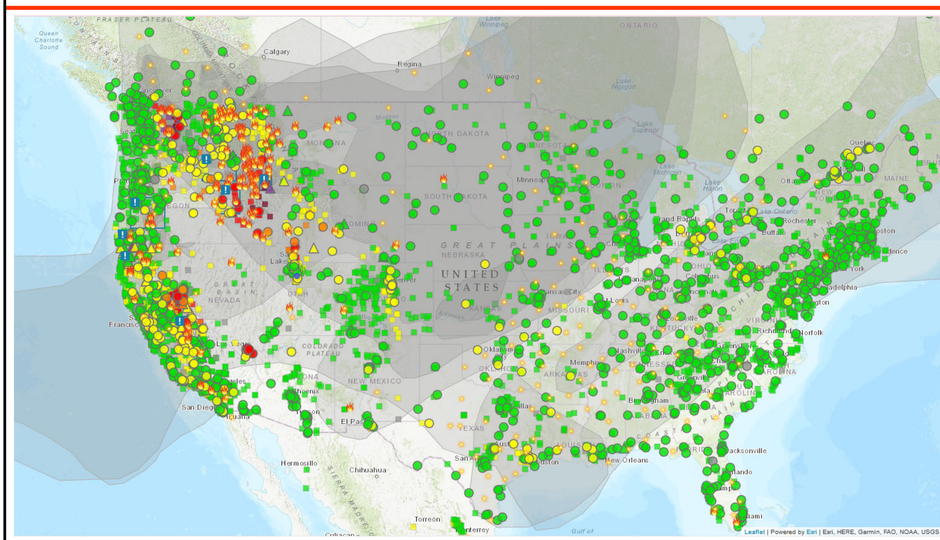
Smoke Map



https://fire.airnow.gov/

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Happy Friday!!!

Fun Video

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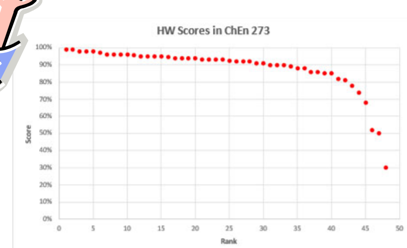
Fatherly Advice

- Don't get behind!



- Draw pictures of process
  - Try not to take shortcuts
  - Work efficiently
  - Find a group to work with
- We will be using Excel
  - Python or Mathcad are also great tools
- The author throws in some "think about it" problems
  - This coincides with a college initiative on innovation
  - Have fun with it; use engineering intuition

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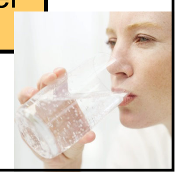
Outline for Class 5

- Define “Independent Equations”
- Degree of Freedom Analysis (DOF)
  - Procedure
  - Examples
- Define “Other Relations”

- Please write in the front cover of 3rd Edition:

ρ_{H2O} = 1 g/cm^3 = 1000 kg/m^3 = 62.4 lb$_m$/ft^3 = 1 kg/liter



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Degrees of Freedom Analysis

- Method to attack problems
- Kind of like # of eqns = # of unknowns
- Can tell where to start a problem
- **DOF required for all remaining problems in Chapter 4**

From my Mother-In-Law:

If you don’t listen you gotta feel

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Independent Equations

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Who Can Solve the Following Equations?

$$x + 2y = 4$$
$$2x + 4y = 8$$

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DOF in Chem Eng

Non-Reacting Systems

- Equations come from material balances
- # independent balance eqns = # species

Common mistake:

- Write all species balances plus overall balance
  - Not all independent

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Example: 2 species

Species Balances:

$x_{A1}m_1 + x_{A2}m_2 = x_{A3}m_3$

$x_{B1}m_1 + x_{B2}m_2 = x_{B3}m_3$

Total Mass Balance

$m_1 + m_2 = m_3$

Only 2 of the 3 balance equations are independent

$x_{A1} + x_{B1} = 1$,   etc.
So if I add the first two equations, I get the third!

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Additional Equations

- Equations other than material balance equations are sometimes given
- Often necessary to solve the problem
- Relate some of the unknown variables

Example:

- 95% of the feed ends up in stream 1

$$\dot{m}_1 = 0.95\dot{m}_{feed}$$

For DOF analysis, DO NOT SOLVE YET!

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DOF for Non-Reacting Systems

unknowns — # of Unknowns

\- # independent balance equations

\- # of additional relationships — # of Equations

DOF

- Formal method
- Useful for complicated systems (tells you where to start)

If
- DOF = 0 good! (unique solution possible)
- DOF > 0 No unique solution (too many unknowns)
- DOF < 0 Over-specified (too many eqns, or one eqn may not be independent)

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Analogy to Sudoku

	8	6	4		3	1		
3		2	5		8			
	4		9	6				
4	7	8				9		6
	5						3	
1		3				2	7	4
				9	4		1	
			1		5	7		9
		5	3		2	4	6	

- How would you set up a logic diagram to solve any sudoku puzzle?
  - Is it solvable?
  - Where do you start?

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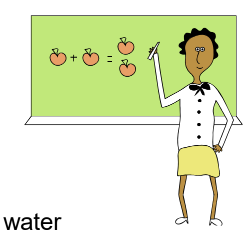
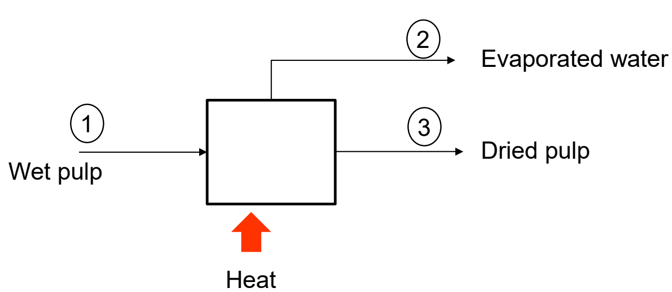
Example 1
(on handout)

A wet paper pulp contains 71 wt% water. After drying, it is found that 60 wt% of the original water has been removed. What is the composition of the dried pulp?





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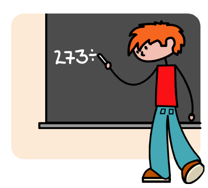
Helpful Hints on DOF

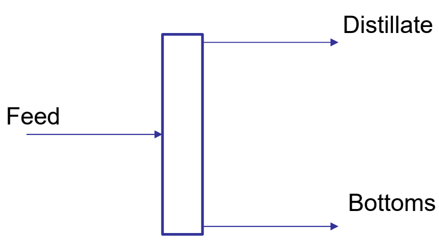
1. Use species flow rates (m_{1A}, m_{1B}, etc.) if possible instead of mole fractions (y_{1A}, etc.)
2. Remember that one species mass or mole fraction is not independent ($\Sigma y_i = 1$)
3. If only one species mass or mole fraction in a stream is unknown, calculate it and treat it as known
4. It is often easiest to use the total mass balance as one equation instead of all of the species balances
5. Use the flow rate given in the problem as the basis
   - Choose a basis if only mass fractions are given
6. If you know the densities and volumetric flow rates, calculate mass flow rates immediately

Example 2

(on back of handout)

A mixture containing 10 % EtOH and 90% H_2O by weight is fed to a distillation column at the rate of 1000 kg/h. The distillate contains 60 wt% EtOH. The distillate flow rate is 1/10th that of the feed. What is the composition and flow rate of the bottoms?





Other Examples

- Prob 4.24 (4.15 in 3rd Ed.)
- Prob 4.18 (4.12 in 3rd Ed.) (if time)

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Problem 4.24
(4.15 in 3rd Edition)

A liquid mixture contains 60.0 wt% ethanol (E), 5.0 wt% of a dissolved solute (S), and the balance water. A stream of this mixture is fed to a continuous distillation column operating at steady state. Product streams emerge at the top and bottom of the column. The column design calls for the product streams to have equal mass flow rates and for the top stream to contain 90.0 wt% ethanol and no S. Assume a basis of 100 kg/hr of feed stream.

(a) Draw the picture
(b) Perform the DOF

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Example Problem 4.18*

(4.12 in 3rd Edition)

(*I changed this problem slightly)

One thousand kilograms per hour of a mixture containing equal parts by mass of methanol and water is distilled. Product streams leave the top and the bottom of the distillation column. The flow rate of the bottom stream is measured and found to be 673 kg/h, and the overhead stream is analyzed and found to contain 60.0% of the methanol fed to the column.

(a) Draw the picture

(b) Perform the DOF

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