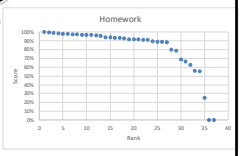
Happy Monday!!!

Fun Video

Fatherly Advice



- Don't get behind!
- Draw pictures of process
  - Try not to take shortcuts
  - Work efficiently
- We will not be using E-Z Solve
  - We have Mathcad and Excel
- There is a lot of reading in the workbook on Problem 4.11 (4.17 in 4th Ed.), but it is worth it!!
  - Workbook pages are optional on all starred problems
- The author throws in some "think about it" problems
  - This coincides with a college initiative on innovation
  - Have fun with it; use engineering intuition

Outline for Class 6

- 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

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

Independent Equations

Who Can Solve the Following Equations?

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

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

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

$m_1 + m_2 = m_3$

$x_{A1} + x_{B1} = 1$, etc.

Only 2 of the 3 balance equations are independent

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!

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)

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?

Example 1

(on handout)

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)

Other Examples

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