ChEn 273
Class 1

• Course Introduction
• Units and unit conversions
• Significant figures
• Process Flow Diagrams
• Stream variables

Course Objectives

A. Obtain a feel for what Chemical Engineers do
B. Learn about basic chemical process units
C. Learn to analyze and solve material balance problems
D. Learn to analyze and solve energy balance problems
E. Learn to analyze more complex balance problems involving coupling of material and energy balances for multiple units

We meet in 393 CB

http://www.arb.ca.gov/fuels/carefinery/crseam/crseam.htm

In your ChE job you may use the skills from this class more than from any other ChE class
(based on feedback from many students)

BYU STEM Career Fair

• Thursday, September 21
• Get your resume on BYU Bridge
• Learn which companies are coming
• Only 25-30% of our students obtain a job through the Career Fair
• YOU have to find a job
  – No one will do it for you
  – Time to start NOW!
**Prerequisites**

- **ChEn 263**  
  - Concurrent enrollment is permitted
- **Calculus**  
  - Know how to do simple derivatives and integrals (i.e., polynomials)
  - We will use one form of ordinary differential equations which will be solved like an integral
- **Chemistry**  
  - Chem 112 or 106 (or concurrent enrollment by permission)

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**Grades**

- **20%** Homework problems, Quizzes, In-Class Activities
- **10%** Case study
- **45%** Three midterm exams  
  (in testing center, closed book with 3x5 note card) (10-15-20)
- **25%** Final Exam  
  - Must get 60% on final to avoid penalty!

2 Dean’s lectures or equivalent required

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**TAs are your friends!**

206 CB  
(schedule TBA)

Landon Nuttall  
Landonut35@gmail.com

Hunter Lee  
hunterjlee95@gmail.com

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**TA Hours Survey**

<table>
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<th>Th</th>
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Reporting 18

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**My Schedule**

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<tr>
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<th>W</th>
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<th>F</th>
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<td>214 CB</td>
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<td>4:00</td>
<td>Graduate Seminar</td>
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**Quiz:**

1. Read the entire syllabus
2. Find the TA room (206 CB)
3. Contact one TA before next class personally!!!
   - Email
   - Phone
   - In person

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Advice

Be Professional!
- You are an apprentice engineer
- Treat this class like your job!
- Keep up with the pace!
- Come to class & pay attention!
- Come see me!

Homework rules:
- Homework problems are due at the beginning of class. Please don’t be late to class because you are finishing homework.
- Homework may be turned in late until the next exam without excuse for up to 50% credit. You may look at the answer key in Learning Suite for guidance on late homework. Dr. Fletcher will excuse late homework on a case-by-case basis. Please work the homework early to avoid lateness due to computer crashes.
- Answer keys will be posted on Learning Suite after class.
- You may discuss with others how to begin working problems (in fact this is encouraged), but you must work the problem entirely yourself to hand in for credit. You may not share computer files for homework problems until the case study.
- Homework should be written on one side only of 8.5” x 11” paper. Neatness is essential in developing good problem solving techniques. Points may be taken off for sloppiness.
- Use of Mathcad will not be permitted on some assignments and encouraged on others. This will be made clear on the class schedule.

Class Details

- Personal Info Sheet
  - Alias name used to post grades
  - Due by Wednesday
- Schedule
- Competencies
- AIChE Code of Conduct
- Class web page

Learning Philosophy

- There are way too many problems in ChE to try to go through an example on each type of problem, like perhaps in a Math class.
- We will learn the basic principles in class, and then give a few HW problems to reinforce those principles
  - “Learn to fish”
- The goals are to learn the basic principles and be able to apply those principles to solve engineering problems
- This method is kind of like being on a job:
  - You will be given a problem and told to solve it with whatever method you can

Learning Philosophy

- Re-reading the chapter(s) just before the exam does no good
- Learn the concepts
  - Do they make sense?
  - Apply to real life
  - Review throughout the semester (more frequent quizzes?)
- Homework with a purpose
  - Why was the problem given?
  - Does my answer make sense?
  - Debugging skills
    - Pieces of problem can be debugged
- Education vs. Degree
  - Job skills vs. a piece of paper

Bloom’s Taxonomy

https://cft.vanderbilt.edu/guides-sub-pages/bloom's-taxonomy/
Textbook

- 4th Edition
  - 3-ring binder (get it spiral bound)
  - Online (this may only be available for one semester)

- 3rd Edition
  - Black & Red cover better
  - Blue and Red cover okay
  - Workbook

Ethics (see Syllabus)

- Only look at previous semester exam
  - I will post the previous year exam with final answers

- Illegal online HW answer keys
  - How much is your integrity worth?
  - Education vs. degree

Questions?

Chapter 2

Units
Estimation
Significant Figures

Practice Unit Conversions

- Pressure is 1300 psi (lb/sq. in.)
  - What is the pressure in atmospheres?
    - \((1300 \text{ psi}) \cdot \left( \frac{1 \text{ atm}}{14.696 \text{ psi}} \right) = 88.46 \text{ atm} \)
  - What is the pressure in mm Hg?
    - \((1300 \text{ psi}) \cdot \left( \frac{760 \text{ mm Hg}}{14.696 \text{ psi}} \right) = 6.723 \times 10^4 \text{ mm Hg} \)

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Equivalent Values</th>
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<tbody>
<tr>
<td>Mass</td>
<td>1 kg = 1000 g = 0.001 metric ton = 2.20462 lbm = 35.2739 kg</td>
</tr>
<tr>
<td>Length</td>
<td>1 m = 100 cm = 1000 mm = 10 mm (micron) (μm) = 10^7 angstroms (Å) = 3.2808 ft = 39.3701 inches</td>
</tr>
<tr>
<td>Volume</td>
<td>1 m³ = 1000 L = 10^6 cm³ = 10^9 mL</td>
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<tr>
<td>Force</td>
<td>1 N = 1 kg m/s² = 10^5 dynes = 10^9 g m/s²</td>
</tr>
<tr>
<td>Pressure</td>
<td>1 atm = 1.01325 × 10^5 Pa = 1.03324 × 10^4 mm Hg</td>
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<tr>
<td>Energy</td>
<td>1 J = 1 N m = 10^3 ergs = 10^6 dynes cm</td>
</tr>
<tr>
<td>Power</td>
<td>1 W = 1 J/s = 1000 mW = 1.356 × 10⁻⁴ hp</td>
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Factors for Unit Conversions
Units of Force

<table>
<thead>
<tr>
<th>System</th>
<th>Mass</th>
<th>Length</th>
<th>Time</th>
<th>Force</th>
<th>( \bar{g} )</th>
<th>( \bar{g}/g )</th>
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<tbody>
<tr>
<td>SI (System International d'unites)</td>
<td>kg</td>
<td>m</td>
<td>s</td>
<td>N</td>
<td>1 kg·m/s²·N</td>
<td>9.807 m/s²</td>
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<tr>
<td>CGS</td>
<td>g</td>
<td>cm</td>
<td>s</td>
<td>dyne</td>
<td>1 g·cm/s²·dyne</td>
<td>980.7 cm/s²</td>
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<tr>
<td>FPS</td>
<td>lb_m</td>
<td>ft</td>
<td>s</td>
<td>poundal</td>
<td>1 ft-lb/s²·poundal</td>
<td>32.17 ft/s²</td>
</tr>
<tr>
<td>British (physical)</td>
<td>slug</td>
<td>ft</td>
<td>s</td>
<td>lb_f</td>
<td>1 ft-slug/s²·lb_f</td>
<td>32.17 ft/s²</td>
</tr>
<tr>
<td>AES (American Engineering System)</td>
<td>lb_m</td>
<td>ft</td>
<td>s</td>
<td>lb_f</td>
<td>32.17 lb_m·ft/(lb_f·s²)</td>
<td>32.17 ft/s²</td>
</tr>
</tbody>
</table>

Bottom line: 1 lb_m = 1 lb_f (under normal gravity), but 1 kg weighs 9.807 N!

New Concepts

- Pounds mass (lb_m)
- Pound moles (lb moles)
- \( 1 \text{ lb}_m = 454 \text{ grams} \)
- \( 1 \text{ lb mol} = 454 \text{ gram moles} \)

LeBron James

- Weighs 250 pounds
- Is this 250 lb_m or 250 lb_f?

Derivation of \( g_c \)

250 lb_m weighs 250 lb_f (on earth with earth’s gravity)

But \( W = \frac{m \cdot g}{g_c} \)

250 lb_f = \( (250 \text{ lb}_m \times 32.17 \text{ ft}/\text{s}^2) / g_c \)

Solving for \( g_c \):

\[ g_c = \frac{32.17 (\text{lb}_m \cdot \text{ft})}{(\text{lb}_f \cdot \text{s}^2)} \]

Always need to use \( g_c \) when converting between lb_m and lb_f

Note: \( g_c \) defined based on earth gravity only, and is a constant!

Example

- What would a LeBron James weigh in tight fighter jet turn that pulls 4 g’s? (i.e., \( g = 4 \) times that of earth)

Solution:

\[ g = 4(32.17 \text{ ft/s}^2) = 128.7 \text{ ft/s}^2 \]

\[ m = 250 \text{ lb}_m \]

\[ W = \frac{mg}{g_c} = \frac{(250 \text{ lb}_m)(128.7 \text{ ft/s}^2)}{32.17 \frac{\text{lb}_m \cdot \text{ft}}{\text{lb}_f \cdot \text{s}^2}} = 1000 \text{ lb}_f \]

Note: value of \( g_c \) does not change with \( g \)

Estimation

- How much coal is in a train car?
  - Length = 20 ft
  - Width = 6 ft
  - Depth = 10 ft
  - Density = 1.4 times density of water
  - Water Density = 62.4 lbm/ft³
  - Packing factor = 0.7

\[ 20 \times 6 \times 10 \times 1.4 \times 62.4 \times 0.7 =? \]

\[ 2 \times 10^1 \cdot 6 \cdot 10 \cdot 6 \times 10^1 \cdot 1 = 72 \times 10^3 \text{ lb}_m \]

36 tons (real answer = 36.6 tons)
Significant Figures

- **Addition/Subtraction**: Compare position of last significant figure relative to the decimal point. The position farthest left is the last permissible significant figure for the sum or difference.
  
  \[ 3.23 + 4.125429 = 7.39 \]

- **Multiplication/Division**: The number of significant figures in the product or quotient is equal to the lowest number of significant figures of any of the numbers being multiplied or divided.
  
  \[ 3.23 \times 4.125429 = 13.33 \]

**Bottom line: Be Reasonable!**

Process Flow Diagram (PFD)

Simple PFD (with information on diagram)

Stream Variables

- **Extensive**: depend on the amount of material (e.g., flow rate, mass, moles)
- **Intensive**: do not depend on amount (e.g., mole fraction or temperature)

- Precision of numbers- significant figures
- Numbers must have units!