

ChE 400: Problem Solving Methodology (H-2)

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It is recommended that you read chapter 11 of Felder and
Rousseau: Elementary Principles of Chemical processes.

Objectives

- General
 - Derive the mathematical expression (s) that describes the performance of a system
- Specific
 - Define a system
 - Recognize types of variables (dependent, independent)
 - Draw a schematic diagram of the problem
 - Use the methodology for problem solving
 - Identify the objective of a problem
 - Formulate the material balance for a system
 - Steady state
 - Unsteady state
 - Constant/non constant volume
 - Select assumptions for the problem
 - Underline the main mathematical expression (governing equation/s)

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Problem Solving Introduction

Problem Solving
- Introduction
- System
- Types of variables
- Why doing this?
- How to do it?
Steps for Problem Solving
Exercises

- In general sense, the performance of the system can be represented as a functional relationship:

dependent variable = f(independent variable)



Expression also known as
objective of the problem (what
do you need to find?)

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Problem Solving - Introduction - System - Types of variables - Why doing this? - How to do it? Steps for Problem Solving Exercises	<h2>System</h2> <hr/>
	<ul style="list-style-type: none"> • Defined section of the universe that we are interesting in studying • In a system we can identify: dependent variables, independent variables, boundaries, and parameters • Exercise 1: - Think of some examples of systems
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Problem Solving - Introduction - System - Types of variables - Why doing this? - How to do it? Steps for Problem Solving Exercises	<h2>Dependent Variable</h2> <hr/>
	<ul style="list-style-type: none"> • Characteristic that reflects the behavior or state of the system • e.g.: temperature, concentration, velocity
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Problem Solving - Introduction - System - Types of variables - Why doing this? - How to do it? Steps for Problem Solving Exercises	<h2>Independent Variable</h2> <hr/>
	<ul style="list-style-type: none"> • Their change produces a change on the system, but they are not affected by changes on the system • e.g.: time, dimensions (x, y, z, r, etc)
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Problem Solving - Introduction - System - Types of variables - Why doing this? - How to do it? Steps for Problem Solving Exercises	<h2 style="margin: 0;">Parameters</h2> <hr style="border: 1px solid black;"/>
	<ul style="list-style-type: none"> • Information that stays constant in the system. Reflective of the system's property • e.g., some properties which do not change (density)
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Problem Solving - Introduction - System - Types of variables - Why doing this? - How to do it? Steps for Problem Solving Exercises	<h2 style="margin: 0;">Solution of the Problem Why?</h2> <hr style="border: 1px solid black;"/>
	<pre> graph TD A([Equation (s)]) --> B([Experimental Data]) A --> C([Physical Insight]) B <--> C </pre>
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Problem Solving - Introduction - System - Types of variables - Why doing this? - How to do it? Steps for Problem Solving Exercises	<h2 style="margin: 0;">Why do we need to do this?</h2> <hr style="border: 1px solid black;"/>
	<ul style="list-style-type: none"> • Equations/models provide an explanation for the physical insight of a process. • Explain the behavior of experimental data. • Allow predicting performance of a process. • Provide a fundamental tool for the optimization and design of the process. • Save Money.
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<p>Problem Solving</p> <ul style="list-style-type: none"> - Introduction - System - Types of variables - Why doing this? - How to do it? <p>Steps for Problem Solving Exercises</p>	<h2 style="text-align: center;">How are we going to get the equations?</h2> <hr/> <ul style="list-style-type: none"> In real life equations that describe the performance of a system are derived by using: <ul style="list-style-type: none"> - Laws of physics - Fundamentals of Chemistry - Material Balance (steady and unsteady state). We will solve differential equations in time dimension <p style="text-align: right; font-size: small;">ChE 400 9/6/2006 10</p>
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<p>Problem Solving</p> <ul style="list-style-type: none"> - Introduction - System - Types of variables - Why doing this? - How to do it? <p>Steps for Problem Solving Exercises</p>	<h2 style="text-align: center;">Steps for Problem Solving</h2> <div style="text-align: center;"> <pre> graph TD A[PROBLEM DESCRIPTION] --> B[DRAW SCHEMATIC] B --> C[ASSUMPTIONS] C --> D[DEVELOP SET OF EQUATIONS: Governing Equations] D --> E[IDENTIFY MATHEMATICAL FORM] E --> F[DEVELOP A STRATEGY] F --> G[ANALYTICAL] F --> H[NUMERICAL] G --> I[WRITE ALGORITHM] H --> I </pre> </div> <p style="text-align: center; font-size: small;">ChE 400 11</p>
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<p>Problem Solving</p> <ul style="list-style-type: none"> - Introduction - System - Types of variables - Why doing this? - How to do it? <p>Steps for Problem Solving Exercises</p>	<h2 style="text-align: center;">Problem description</h2> <hr/> <ul style="list-style-type: none"> Read carefully the problem statement This step is coupled with the schematic diagram Identify variables and parameters <ul style="list-style-type: none"> - Dependent - Independent - Parameters Define the symbols for your variables Write down objective function (use your own symbols) <p style="text-align: center; margin-top: 10px;"> dependent variable = f(independent variable) </p> <p style="text-align: right; font-size: small;">12</p>
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Problem Solving - Introduction - System - Types of variables - Why doing this? - How to do it? Steps for Problem Solving Exercises	<h2>Problem description</h2> <h3>Common Mistakes</h3> <hr/>
	<ul style="list-style-type: none"> • Forgot to define your symbols (then I won't be able to understand) • Forgot to define the objective function • Variables do not identify and classified • Poor understanding of the statement <ul style="list-style-type: none"> - Read, read, and read again to avoid this problem
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Problem Solving - Introduction - System - Types of variables - Why doing this? - How to do it? Steps for Problem Solving Exercises	<h2>Draw Schematic</h2> <hr/>
	<ul style="list-style-type: none"> • After understanding the problem statement you should be able to draw a schematic representation of the situation <ul style="list-style-type: none"> - If I don't provide a schematic you need to develop one from scratch - If I provide a schematic, you need to redraw it with all the details needed • Label your streams • Use the symbols defined in the problem description
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Problem Solving - Introduction - System - Types of variables - Why doing this? - How to do it? Steps for Problem Solving Exercises	<h2>Schematic</h2> <h3>Common Mistakes</h3> <hr/>
	<ul style="list-style-type: none"> • Forgot to draw schematic (then I can't understand your solution) • Forgot to redraw schematic including all details and symbols (I can't understand your solution) • Didn't include symbols in the schematic (I can't understand your solution)
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Problem Solving - Introduction - System - Types of variables - Why doing this? - How to do it? Steps for Problem Solving Exercises	<h2>Assumptions</h2> <hr/>
	<ul style="list-style-type: none"> • In problem solving assumptions are defined as: <ul style="list-style-type: none"> - All the information that is considered to make our model/equations work. This information tells the user under what conditions the model/equations will work (e.g., constant volume) - If the user tries to use the equations at different conditions the model will produce wrong results • Write down all the assumptions of your equations/model, including given data • Hint: Typically assumptions are used to simplify the material or energy balance <p style="text-align: right;">ChE 400 9/6/2006 16</p>

Problem Solving - Introduction - System - Types of variables - Why doing this? - How to do it? Steps for Problem Solving Exercises	<h2>Assumptions Common mistakes</h2> <hr/>
	<ul style="list-style-type: none"> • Did not provide all the assumptions of the model/equations • Confuse the definition of what an assumption is <ul style="list-style-type: none"> - Remember, even given data can be an assumption of the model - Assumptions is everything that makes our model/equations work <p style="text-align: right;">ChE 400 9/6/2006 17</p>

Problem Solving - Introduction - System - Types of variables - Why doing this? - How to do it? Steps for Problem Solving Exercises	<h2>Develop Set of Equations</h2> <hr/>
	<ul style="list-style-type: none"> • Use laws of physics, chemistry, thermodynamics, material balance, energy balance to develop equation • Apply assumptions • Simplify expression • Final expression is known as the governing equation <ul style="list-style-type: none"> - It may be an algebraic equation or set of algebraic equations - It may be a differential equation or set of differential equations <p style="text-align: right;">ChE 400 9/6/2006 18</p>

Problem Solving - Introduction - System - Types of variables - Why doing this? - How to do it? Steps for Problem Solving Exercises	<h2>Develop Set of Equations Common Mistakes</h2> <hr/>
	<ul style="list-style-type: none"> • Do not know how to apply material balance (chemistry and physics principles) properly <ul style="list-style-type: none"> - Advice: Need to know the content of What you must know (http://www.ent.ohiou.edu/che/che400/What%20you%20must%20know.pdf) • Jump steps • Did not simplify equations properly (by using the equation) <p style="text-align: right; font-size: small;">ChE 400 9/6/2006 19</p>

Problem Solving - Introduction - System - Types of variables - Why doing this? - How to do it? Steps for Problem Solving Exercises	<h2>Identify Mathematical Form</h2> <hr/>
	<ul style="list-style-type: none"> • Use the material learned in class to identify the type of equation to be solved • Need to say what type of equation is, examples: <ul style="list-style-type: none"> - Linear algebraic equations - Ordinary differential equation, etc <p style="text-align: right; font-size: small;">ChE 400 9/6/2006 20</p>

Problem Solving - Introduction - System - Types of variables - Why doing this? - How to do it? Steps for Problem Solving Exercises	<h2>Identify Mathematical Form Common Mistakes</h2> <hr/>
	<ul style="list-style-type: none"> • Confusion of techniques • Advices: <ul style="list-style-type: none"> - Read and study material of the class continuously. - Waiting until the last moment will cause confusion of the techniques - First study the material of the course before trying to solve the homework - Do the homework on your own <p style="text-align: right; font-size: small;">ChE 400 9/6/2006 21</p>

Problem Solving - Introduction - System - Types of variables - Why doing this? - How to do it? Steps for Problem Solving Exercises	<h2>Mathematical Problems that You will find in this course</h2> <hr/> <ul style="list-style-type: none"> • Roots of Equations • Systems of Linear Algebraic Equations • Non-linear algebraic equations • Integration/differentiation • Ordinary Differential Equations
	<p style="text-align: right;">ChE 400 9/6/2006 22</p>

Problem Solving - Introduction - System - Types of variables - Why doing this? - How to do it? Steps for Problem Solving Exercises	<h2>Develop a Strategy</h2> <hr/> <ul style="list-style-type: none"> • Once you have identified the type of equation (s) to solve you should choose a strategy of solution <ul style="list-style-type: none"> - Analytical - Numerical (write algorithm)
	<p style="text-align: right;">ChE 400 9/6/2006 23</p>

Problem Solving - Introduction - System - Types of variables - Why doing this? - How to do it? Steps for Problem Solving Exercises	<h2>Properties</h2> <hr/> <ul style="list-style-type: none"> • An important factor to consider when modeling a system is the properties required by the model • A model will be as good as the data used: <ul style="list-style-type: none"> - Poor input, poor results - Good input, good results • Properties can be determined by <ul style="list-style-type: none"> - Experiments - Molecular simulations
	<p style="text-align: right;">ChE 400 9/6/2006 24</p>
