Problem Solving

There are two objectives for each problem/project in this course:

Solve the Problem

Improve your Problem Solving Abilities to Use in Other Areas

Mindset: Getting Better

Put Yourself in the Good Frame of Mind

Confidence/Relaxation Techniques

Expect to be confused and be able to work through it

Own the Responsibility and Necessity to Solve the Problem

Persist

Difficult problems take more time and more than one session.

Resourcefulness/Creativity

Use Knowledge/Analogies for other areas

Proceed in steps:

1. Generate an idea or proposal.

2. Realize that mistakes and choosing wrong directions are inherent in the process.

3. Explore where the idea takes you in understanding the problem.

4. After each attempt, use the experience to pick up a clue from the result, make a change or discard it and try again.

Problem Solving Steps (Adapted from Wankat & Oreovicz)
(https://engineering.purdue.edu/ChE/AboutUs/Publications/TeachingEng/chapter5.pdf)

Step		
0	Mindset: Getting Better	Responsibility Persistence Resourcefulness/Creativity
1	Define	List knowns, unknowns, and constraints. Draw a figure. Understand what the solution looks like.
2	Explore	Think about it—Ideas will arise as you explore the details Ask yourself questions to see different perspectives e.g. What happens at the limits? How does this problem resemble previous problems? How is it different? Is intermediate information (or intermediate steps) required?
3	Plan	Draw concept map for multi-step problems. Decide on an approach to the problem. Consider heuristics and algorithms. Solve appropriate equations without numbers, isolate variable.
4	Do it	Substitute numbers and calculate results.
5	Check	Evaluate against experience for reasonableness. Check for algebraic and mathematical errors.
6	Generalize	What are wider applications of the result? How could the problem been more efficiently solved in the future? If the problem was not solved, what should have been done differently?

Assignment: Individual Analysis to Identify Skills to Strengthen

Most problems are so routine that the answers are obvious and they are not really problems at all. As a consequence, people get in the habit of just jumping in and delivering the first answer that comes to mind. A method is not necessary. This experience gives rise to the idea that all problems can be solved in an informal style.

However, when difficult problems are encountered (either in science or life), a more informed analysis is required to resolve the problem.

The most effective way to improve your ability to solve difficult problems is to identify the steps of the problem solving process that are the weakest and work to strengthen those. This approach is a much more efficient use of time than putting equal attention on all steps.

In the last week, you have had both individual and group work with a number of problems.
Recall how you worked on these problems and use that experience as guidance for the steps below:

Use of the Problem Solving Method

Do you know the steps in your head? If not, learn them.
Did you use it explicitly?

Self-Evaluation Rating Worksheet

This worksheet lists specific examples of behaviors used by novices and experts in the problem solving process.

Based on your experience with the problems in class and homework, rate yourself on a scale of 1-4 for each behavior. Use this to identify the steps that you will benefit the most by working on.

Developing Expertise Worksheet

Using the 1 or 2 steps which need the most attention, use the Developing Expertise worksheet to get some specific ideas on changes you can make in your own personal problem solving style.

Document your plan

Write down the changes that you are going to make.
List ways that you can check on yourself to see if you are making them

Accountability

Print out two copies of your plan. Hand in one to me at the next class.
Have your copy of the plan in front of you for the next few classes to monitor your progress in making changes.

Problem Solving Self-Evaluation Worksheet

Name

Problem

In problem solving, you are only as strong as your weakest link. The most efficient way to improve your skills is to first identify your strengths and weaknesses and then focus on steps to improve the appropriate areas. This approach is far more effective than reviewing what you are already good at.

For the selected problem, rate yourself for each step using the novice/expert criteria shown below. Select the two that you rated the lowest and target them for special attention.

Problem Solving Step **Reference**	**Skill**	**Novice**	**Expert**	**Rating (1-4)**
0 Mindset	Attitude Persistence	Try once and give up	Can-do with persistence, Confident	
0 Evidence and Comments				
1 Define	Problem Statement	Difficult to restate Jump to conclusion	Different ways to restate Take time to define problem	
1. Evidence and Comments				
Problem Solving Step **Reference**	**Skill**	**Novice**	**Expert**	**Rating (1-4)**
2. Explore	Strategy	Trial and Error	Uses definite approach and strategy	
2. Explore	Information	Difficulty recognizing relevant information Cannot draw inferences from incomplete data	Recognizes key information Can draw inferences	
2. Explore	Sketches	Not done	Sketches explored	

2. Evidence and Comments				
Problem Solving Step **Reference**	**Skill**	**Novice**	**Expert**	**Rating (1-4)**
3. Plan	Breaking into (multi-step problems)	Not analyzed in parts	Analyzed in parts Done in sequential steps	
3. Evidence and Comments				
4. Do it	Monitor progress	Not done	Keep track Monitored against strategy	
4. Do it	If stuck	Guess Give up	Use Heuristics Brainstorm Persist	
4. Do it	Actions	Stare into space	Use pencil, ask yourself questions	
4. Evidence and Comments				
5 Check	Accuracy/ Evaluation	Not checked	Checked Compared to experience	
5. Evidence and Comments				
6. Generalize	Follow-up	Accept result and move on	Learn and internalize what should have been done	
6. Evidence and Comments				

Problem Solving: Developing Expertise based on Self-Evaluation

Based on your self-evaluation, consider these changes for the step that you need to develop expertise

Step		Changes
0	Mindset	**Expect to be confused and frustrated** **"**I have no idea what to do." Confusion and frustration are part of the process of learning. The important point is not to be defeated by them. Everyone in a college course has the ability to do the assigned problems. No exceptions, you have gotten into the college program. The problems may be difficult and require significant effort, but you should be confident that you can do them. After you work through confusion a few times, confidence (and persistence) will begin to grow. Experiencing confusion and frustration is similar to weathering a summer storm. The storm often comes on suddenly and strongly, but then it passes and the sunshine returns.
1	Define	There is a tendency just to do the problem, without knowing what the solution even looks like. Defining the problem is really about assessing what is needed and what is available. Ask yourself: What does the solution look like? (Express in both words and units.) What is the meaning of the information available in the problem? What are the relationships (equations) between the solution and available data?
2	Explore	**Identify a Known Starting Point--The first step to ending confusion** Suppose that you fall down a steep hill. First you grab on something to stop the fall. Then, you pull yourself back up a step at a time using rocks, trees or whatever is within reach to grab on and use. Getting started on a problem is like that. Read the problem with the intent to understand the words and content, not to solve it. If you are not clear how to begin, take a step back and find a fact that you do know. The important point is to find a foothold to begin. Example Starting Points: A worked out example A definition of a key word that is in the problem A diagram A short conversation with a classmate or a teacher It is important that you look and find a starting point to progress, rather than allowing time to go by. **Make a concept map or flow diagram and to gain insight into n how information is related**
3	Plan	**If you have worked examples available, COVER the solution and work it out yourself.** If the examples are not understood, it is usually a waste of time to spend much effort on the new problem before understanding this. Go back to the earlier step and find a new starting point. After doing the example yourself, read the new problem slowly, understand what it is stating and what it is asking. **See how the information in the new problem relates to the earlier**

		examples. The examples will show you which formulas or equations are needed. Formulas are the key that turns the words of a problem into symbols. **It usually is essential to draw a diagram.** **Evaluate the different heuristic strategies to see if they are appropriate to all or parts of the problem.** Use with your flow diagram or concept chart.
4	Do it	**Stay organized so that it is easy to retrace your logic** when you make a mistake. Write slowly and neatly. Sloppy writing leads to errors. Leave plenty of blank space to make it easier to follow. Errors are part of the process and it is much faster to find them when the work can be easily traced back. There is the temptation to just write things down and hope for the best. This approach takes more time in the long run. **Make the units work for you.** Know the units of the final answer to the problem. Keep these in mind so that your solution is consistent. Every time you write a number or symbol down, include the unit right after it in clear writing. Keep track of the units throughout. Inconsistent units can alert you to logical errors. When a spicy meal is prepared, the spices are added during the cooking process. They are part of the food. If spices are added when the meal is served, the taste is not nearly as good. Units are like that. Make them an integral part of cooking the problem. **Do the calculations last--after the set-up is right** Get the logic right before you do the math. Then, substitute the numbers for the symbols of the equation. Set up all of the numbers and units before you do the calculation. Doing the calculations at the end makes it easier to distinguish between errors in the logic applied to the problem and math errors. **Watching is not doing: Work it out fully for understanding** Problem solving is a participatory sport, not a spectator sport. Hearing an explanation, or seeing a problem worked out problem is different from being able to do it.
5	Check	**Check for reasonableness and unit consistency** Remember that all of these problems relate to the physical world. In some cases, you may have an idea or estimate of the range that the numerical answer should be. If it is far off, then, you can begin to check.
6	Generalize	Identify and state a technique or relationship that you now understand as a consequence of doing the problem. Keep it in mind in the future. Does this problem look like other problems that you have solved? More likely, can it may be used as a reference for some future problem?