PROBLEM SOLVING FOR SCIENCES & ENGINEERING
What is Your Present Approach to Problem Solving?

Self - Assessment Exercise:

Each of the nine items presents two opposing statements:
- If you feel that the left hand statement describes your approach, circle 0
- If you feel that the right hand statement describes your approach circle 4
- If you feel you are somewhere in between, choose 1, 2, or 3 on the scale

1. I feel that problem-solving courses involve memorizing lots of formulas
   I feel that problem-solving courses involve learning how to apply basic concepts and principles.

   0 1 2 3 4

2. When I am learning a new concept in a problem solving course, I do not know what is important - I just try to learn everything.
   When I am learning a new concept, I focus on learning and understanding the key formula or principle.

   0 1 2 3 4

3. I do not think about the new concepts I am learning.
   I think about the new concepts I am learning in an effort to understand them better.

   0 1 2 3 4

4. I do not do a careful analysis of the solved examples presented.
   I do a careful analysis of the solved examples presented to see how the concept is applied.

   0 1 2 3 4

5. When I look at a solved example I focus on finding formulas that work on actual problems.
   When I look at a solved example, I try to figure out what was done in each step and why.

   0 1 2 3 4
6. When I solve a problem I try to remember or find a formula that I can plug into easily. When I solve a problem I follow steps that apply the relevant concept.

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
</table>

7. Problems that are different from ones I have seen before cause me trouble. Once I have learned a concept well, I am confident I can solve a variety problems involving that concept.

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
</table>

8. When I solve a problem I am happy to get an answer. When I solve a problem I always check to see if my answer seems reasonable.

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
</table>

9. When I ask for help I focus on getting formulas that work and correct answers. When I ask for help I focus on clarifying steps or information that helps me apply the concept correctly.

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
</table>

Total Score: ___ out of 36

If your score is between 0 – 18, you favour the formula-memorizing approach
If your score is between 19 – 36, you favour the conceptual approach

The Conceptual Approach is the most efficient way of solving problems, as it organizes information into a concise format that associates facts, formulas, key words and important information.
Many people avoid problem solving courses such as physics, chemistry and mathematics because they think there are too many formulas to remember and believe the myth that only bright students can do well in these courses.

- Many students put in long hours trying to study and practice solving problems, but often do not do well because of inefficient approaches
- The focus is often on memorizing formulas which is not sufficient for difficult problems

The Formula-Memorizing Approach:

High school science teachers often encourage students to memorize specific formulas that match specific types of problems.

This approach involves:

- Loading your mind with as many facts and formulas it can hold
- Aiming towards getting the right answer
- Finding the right formula and producing the right answer in 1-2 steps
- **Disadvantage:** After high school, the number of formulae increases beyond memory capacity and problems with 'curves' are impossible to solve

The Conceptual Approach:

A more efficient way to solve problems is to focus on understanding a few key concepts that can be applied to many different types of problems. This approach takes a little more time at the beginning, but if we select the important concepts and learn them very well, we will be much more successful in courses with more challenging problems.

This approach involves:

- Developing an ability to collapse a large amount of information into concise concepts
- Learning a small number of key allowable formulas very well and knowing how and when to apply them which makes this knowledge highly transferable in different areas
- Relating new information back to the concept and real life examples where these examples can be analyzed to see how the concept is applied
- After concepts are 'boiled down', identifying the concept needed for each problem becomes simpler
Strategies to Shift from Memorizing Formulas → A Conceptual Approach

Altering your study habits away from memorizing formulas to learning the associations of various concepts will take some time to get used to.

Follow 3 steps towards a Conceptual Approach:

1. **Create a Concept Summary** - Helps to learn and understand a small amount of essential information

2. **Make a List of Decision Steps** - Helps to learn how to apply a specific concept

3. **Keep Track of Difficult Problems Associated with Each Concept** - Helps to classify and anticipate how problems are made difficult

1. **CONCEPT SUMMARY:**
   - Concepts make up the main topics in a course and usually involve powerful general ideas expressed in key formulae
   - There are 5 components of a concept summary which help select and organize the important conceptual information you need to know in order to solve problems involving that concept
5 Components of the Concept Summary:

- **Title:**
  Select a large chunk of connected information (i.e., half of a chapter or unit) which includes five or fewer key allowable formulas that are closely related.
  Example: exponent rules in algebra or Newton's second law of physics

- **Key Allowable Formulas:**
  Identify the key allowable formulas (1-5) which will be the crucial formulas and the only ones you need to memorize. Even if they are memorized, you should understand the components of the formula and how they fit together.

- **Definitions, Units and Symbols:**
  Make sure you know all the definitions, units and symbols of the new terms in each of the key formulas.

- **Additional Important Information:**
  Note any other information that you need to know to use the key formula correctly. These usually include the conditions the key formula can and cannot be applied, the sign conventions, special characteristics, assumed values you need to know, etc.

- **Explanation in Your Own Words:**
  Try to think of how you could explain this concept to someone else, and alternative ways to understand the concept, such as diagrams, graphs, real life examples, etc.

2. **THE DECISION STEPS STRATEGY:**

- Decision steps are based on sound knowledge of the specific concept summary items and used when trying to solve a problem from the information provided.

- Solving problems by solving listing unknowns and knowns and then finding a promising formula is a recipe for disaster.

- Using the key formula may require some special care. It's crucial that the steps involved in making these decisions are identified and then followed correctly.
Making Your Decision Steps:

- **Analyze solved examples**
  - Determine your own initial decision steps and work through the examples, trying to answer these questions for each step in the solution.
  - **What** was done in that step?
  - **How** was it done?
  - **Which** guideline or formula was used?
  - **Why** was it done?
  - Clearly record the steps that were made to set up the given information so that the key formula can be used correctly
  - The decision steps should be brief and focus on the steps you find difficult
  - Create specific formulas from the key allowable formulae, including the steps to derive specific formulae you need for the problem

- **Test your decision steps**
  - Solve similar problems, following your decision steps, and revise steps as needed
  - Follow your decision steps closely - these steps should guide your thinking - Don't be tempted to use a quick formula to get an answer.

- **Continue to use and revise**
  - Solve easy, medium and hard questions which will help to refine your decision steps

3. **DIFFICULT PROBLEMS**
- Keep track of difficult problems and the techniques professors use to test students

<table>
<thead>
<tr>
<th>Hidden Knowns</th>
<th>Information hidden in a phrase or diagram (ie. “at rest” means v=0)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multi-Part I</td>
<td>Same concept: the problem may have 2+ sub-problems, each involving the use of the same concept. The problem can be solved only by identifying the given information in the sub-problems</td>
</tr>
<tr>
<td>Multi-Part II</td>
<td>Different concepts: sub-problems involve the use of different concepts</td>
</tr>
<tr>
<td>Multi-Part III</td>
<td>Simultaneous equations: when one sub-problem can't be solved by itself (ie. 2-3 unknowns and 2-3 equations have to be solved simultaneously)</td>
</tr>
<tr>
<td>Reverse Order</td>
<td>The problem has to be solved in reverse order</td>
</tr>
<tr>
<td>Letters Only</td>
<td>Known quantities are expressed in letters</td>
</tr>
<tr>
<td>“Dummy” Variables</td>
<td>Quantity is not specified because it is not needed</td>
</tr>
<tr>
<td>Red Herring</td>
<td>More information given than is needed to solve the problem</td>
</tr>
</tbody>
</table>
4. PROBLEM SOLVING STRATEGIES

- Work on your problem solving course regularly
  - This is especially important for problem solving courses because the information in these courses is usually sequential
  - When you keep up to date in a course, you can seek help right away from a professor or TA

- Most of your study time should be spent solving problems
  - You should be practicing what you will need to do on the exam rather than reading the text or lecture notes

- Find and do harder problems
  - Tackle the challenging problems that will prepare you the best for the exam

- Give yourself a 15 min time limit for each problem
  - This is the time limit that will most likely be faced on an exam
  - With a time limit, it becomes easier to identify problem areas and work at improving those weak areas

With a little practice, this study strategy will be extremely helpful when it comes to studying for your science, math or engineering exams. Instead of driving yourself crazy with memorizing facts and formulas, the conceptual approach will help you learn by creating associations between concepts and formulas in an organized and concise format.

References:


Conceptual Approach Template:

CONCEPT SUMMARY FOR _________________________

I. KEY ALLOWABLE FORMULAE:

II. DEFINITIONS, UNITS and SYMBOLS:

III. ADDITIONAL IMPORTANT INFORMATION:

IV. EXPLANATION IN YOUR OWN WORDS (DIAGRAM/GRAPH):