CHAPTER 3

PROBLEM SOLVING

3.1. INTRODUCTION

Engineers are problem solvers. Employers hire them specifically for their problem solving skills. It is impossible to teach a specific approach that will always lead to a solution. The only way to learn problem solving is to do it. Thus, your engineering education will require that you solve literally thousands of homework problems.

3.2. TYPES OF PROBLEMS

A problem is a situation, faced by an individual or a group of individuals, for which there is no obvious solution. There are many kinds of problems:

- *Research problems* require that a hypothesis be proved or disproved. A scientist may hypothesize that CFCs (chlorofluorocarbons) are destroying the earth's ozone layer. The problem is to design an experiment that proves or disproves the hypothesis.
- *Knowledge problems* occur when a person encounters a situation that he/she does not understand. A chemical engineer may notice that the chemical plant produces more products when it rains. The cause is not immediately obvious, but further investigation might reveal that heat exchangers are cooled by the rain and hence have more capacity.
- *Troubleshooting problems* occur when equipment behaves in unexpected or improper ways. An electrical engineer may notice that an amplifier has a 50-cycle hum whenever the fluorescent lights are turned on. To solve this problem, he determines that extra shielding is required to isolate the electronics from the 50-cycle radiation emitted by the light.
- *Mathematics problems* are frequently encountered by the engineers, whose general approach is to describe physical phenomena with mathematical models. If a physical phenomenon can be described accurately by a mathematical model, the engineer unleashes the extraordinary power of mathematics, to help solve the problem.
- *Resource problems* are always encountered in the real world. It seems there is never enough time, money, people, or equipment to accomplish the task. Engineers who can get the job done in spite of resource limitations are highly prized and well rewarded.
- *Social problems* can impact engineers in many ways. Cultural level of the people in the region will affect the behavior and efficiency of the workers from the same area.
- *Design problems* are the hearth of engineering. To solve them requires creativity, teamwork, and broad knowledge.

3.3. PROBLEM SOLVING APPROACH

The approach to solving an engineering problem should proceed in an orderly, stepwise fashion. The early steps are qualitative and general, whereas the later steps are more quantitative and specific. The elements of problem solving can be described as follows:

1. *Problem identification* is the step toward solving a problem. For students, this step is done for them when the professor selects the homework problems. In real life, this step is often performed by a manager or a creative engineer.
2. *Synthesis* is a creative step in which parts are integrated together to form a whole.
3. *Analysis* is the step where the whole is dissected into pieces. Most of the formal engineering education will focus on this step. A key aspect of analysis is to translate the physical problem into a mathematical model.
4. *Application* is a process whereby appropriate information is identified for the problem at hand.
5. *Comprehension* is the step which the proper theory and data are used to actually solve the problem.

Solving these five steps may or may not be done in a linear sequence. Often problem solving is an iterative procedure, meaning the sequence must be repeated because information learned at the end of the sequence influences decisions early in the sequence (Figure 3.1).

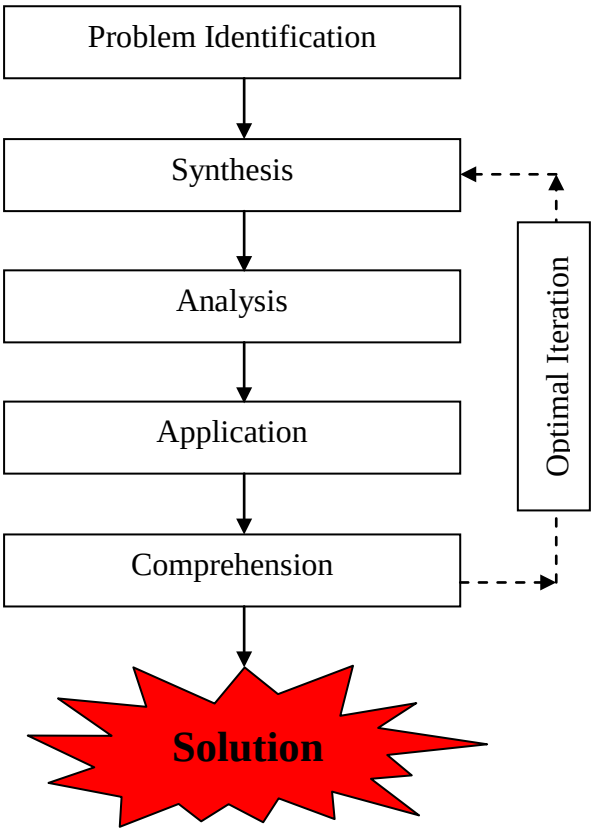


Figure 3.1 Problem solving approcach

3.4. PROBLEM SOLVING SKILLS

Problem solving is a process in which an individual or a team applies knowledge, skill, and understanding to achieve a desired outcome in an unfamiliar situation. The solution is constrained by physical, legal, and economic laws as well as by public opinion. To become a good problem solver, the engineer must have the following:

- Knowledge (first acquired in school, but later on the job),

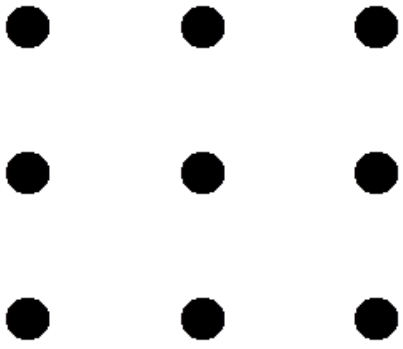
- Experience to wisely apply knowledge,
- Learning skills to acquire new knowledge,
- Motivation to follow through on tough problems,
- Communication and leadership skills to coordinate activities within a team.

Table 3.1 compares skilled and novice problem solvers. Among the most important capabilities of a skilled problem solver is reductionism, the ability to logically break a problem into pieces. (*Question: How do you eat an elephant? Answer: One bite at a time.*)

Table 3.1 Comparison of skilled and novice problem solvers

Characteristic	**Skilled Problem Solver**	**Novice Problem Solver**
Approach	Motivated and persistent Logical Confident Careful	Easily discouraged Not logical Lacks confidence Careless
Knowledge	Understands problem requirements Rereads problems Understands facts and principles	Does not understands problem requirements Relies on a single reading Cannot identify facts and principles
Attack	Breaks the problem into pieces Understand the problem before starting	Attacks the problem all at once Tries to calculate the answer right away
Logic	Uses basic principles Works logically from step to step	Uses intuition and guesses Jumps around randomly
Analysis	Organized Thinks carefully and thoroughly Clearly defines terms	Disorganized Hopes the answer will come Uncertain about the meaning of symbols
Perspective	Has a feel for the correct magnitude of answers Understands the differences between important and unimportant issues Uses rule of thumb to estimate the answer	Uncritically believes the answer produced by the calculator or computer Cannot differentiate between important and unimportant issues Cannot estimate the answer

Example 3.1: The nine dots shown are arranged in equally spaced rows and columns. Connect all nine points with four straight lines without lifting the pencil from the paper and without retracing any line.



3.4. ESTIMATING

The final step in solving a problem is to check the answer. One can accomplish this by working the problem using a completely different method. However, there is generally no time for a different method. Instead, a very valuable approach is to estimate the answer. The ability to estimate comes with experience. After many years of working similar problems, an

engineer can “feel” if the answer is in the right place. It is general experience that most business is conducted over lunch, using napkins for calculations and drawings. An engineer who has the ability to estimate will impress both clients and bosses. Süleyman Demirel says “Engineer is the one who can estimate instantly the cost of a product with 10% accuracy”.

Example 3.2: Estimate the volume of an average sized man.

Solution: People body is mostly composed of water; they do float slightly when swimming. Thus the density must be slightly less than water, accept it as 0.95 g/cm^3. Mass of average man can be taken as 70 kg.

$V = m/\rho = 70{,}000 \text{ g} / 0.95 \text{ g} / \text{cm}^3 = 73{,}684 \text{ cm}^3$