PROBLEM SOLVING

Chapter 3
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Problem Solving

- It is more an ART than it is a SCIENCE.
- Practice, Practice, and practice to get better.
  - We train engineers that can learn.
- Computer is a tool to help you solve the problem, It will not solve the problem, you do.
Types of Problems

- **Research Problem**
  - Prove a hypothesis,
    - CFC destroys ozone layer.

- **Knowledge Problem**
  - Unknown phenomena,
    - higher productivity of chemical plants during rain.
Types of Problems

- Troubleshooting Problem
  - Unexpected behavior of equipment,
    - Computer crashes unexpectedly.

- Mathematics Problem
  - Describe physical phenomena,
    - Build mathematical model.
Types of Problems

- **Resource problem**
  - Always encountered,
    - Doing more with less, Optimize.

- **Social Problems**
  - Social constraints,
    - Shortage of skilled workers, appropriate training program.
Types of Problems

- Design Problem
  - Heart of Engineering,
  - Open Ended problems,
    - Creativity
    - Knowledge
    - Team work
Problem Solving Approach

- Problem Identification
  - Done…. usually by your professor, manager, boss, ….
  - Define what needs to be done.
    - Objective must be clear.
    - Design a revolutionary car to gain back market share.
Problem Solving Approach

- Synthesis
  - A creative process.
  - Integrating the parts to form the whole.
    - Must combine high fuel efficiency with sleek, aerodynamic body.
Problem Solving Approach

- Analysis
  - Most of your formal engineering training.
  - Dissect the problem into smaller pieces in order to understand it better.
  - Translate physical problem into mathematical model.
  - Distinguish truth from opinion.
  - Select relevant information.
  - Identify relationship between parts.
    - Compare drag of different body type and see what size of engine fits them.
Problem Solving Approach

- Application
  - Identify the key questions that solves the problem.
    - What is the required force to propel the car 60 mph knowing projected frontal area is 19 ft$^2$ and drag coefficient is 0.25
Problem Solving Approach

- Comprehension
  - Proper theory and data are used to actually solve the problem.
    - Calculate the required drag force.

DESIGN IS AN ITERATIVE PROCEDURE
Problem Solving Approach

- Identifying the drag force $F$ on the automobile

\[ F = \frac{1}{2} C_d \rho A v^2 \]

- Drag Coefficient (dimensionless)
- Air Density (kg/m$^3$)
- Velocity (m/s)
- Projected Frontal Area (m$^2$)
Problem Solving Approach

\[ F = \frac{1}{2} (0.25)(1.18 \frac{kg}{m^3}) \]

\[ \left[ 19 \text{ ft}^2 \left( \frac{m}{3.281 \text{ ft}} \right) \right] (60 \frac{mi}{hr} \cdot \frac{h}{3600 \text{ s}} \cdot \frac{5280 \text{ ft}}{mi})^2 \frac{N}{k \cdot m \cdot s^2} \]

\[ = 190N \frac{lb}{4.448 N} = 42 \text{ lb} \]
Problem Solving Skills

- The solutions is usually constrained by physical, legal, and economic laws as well as by public opinion.
Problem Solving Skills

- Knowledge
- Experience to apply knowledge
- Learning skills to acquire new knowledge
- Motivation to follow through
- Communication & leadership skills
Problem Solving Skills

- Reductionism
  - It contrasts with synthesis
  - Designing and building subsystems
    - Divide & Conquer (learn from Brits)
  - How do you eat an elephant?
  - One bite at a time.
Techniques for Problem Solving

1. Draw a picture.
2. State assumptions.
3. Indicate given info on figure w/ units.
4. Label unknowns w/ “?”.
5. Write main equations.
6. Detail algebraic manipulations.
7. Insert numerical values w/ units.
Techniques for Problem Solving

8. Check unit cancellations CAREFULLY.
9. Check signs ONE MORE TIME.
10. Compute the answer.
11. Mark the final answer clearly
12. DO NOT FORGET THE UNITS.
13. Does the answer make sense?
14. Did you answer all questions?
Techniques for Problem Solving

- Use engineering paper.
- BE CLEAN
- BE ORGANIZED
- BE PROFESIONAL
- MAKE IT LOOK LIKE AN ENGINEER’S WORK.
Techniques for Problem Solving

- Solve the following problem:
  - A 40 cm log is floating vertically in the water. Determine the length of the log that extends above the water line. Density of water is 1.00 gr/cc and density of wood is 0.60 gr/cc.
Estimating

- Many important business is conducted over lunch.
- You should be able to perform quick calculations on a napkin.
- “Back of an envelope” calculations are mainly estimations.
Estimating

- Can you estimate the surface area of an average size man?
- Can you estimate the volume of an average size man?
- Can you estimate how many bed pillows can fit in the back of a tractor trailer?
Creative Problem Solving

- Scientists study what nature has already created.
- Engineers create from nature what did not exist before.
Creative Problem Solving

- How are engineers stereotyped?
- Why?
- Is it justified?
Creative Problem Solving

- Probably the most misunderstood process of the human intellect.
- What is the nature of “creativity”
- Is it an attribute that is bestowed upon a selected few?
  - Writers
  - Artists
  - Musicians
Creative Problem Solving

- Prerequisites of creativity
  - Mastering the basics
  - Practice, practice, practice, …..

- World is full of intellectually brilliant failures.
Problem Solving Strategy

- Understand the problem
- Devise a plan
- Carry out the plan
- Look back
Problem Solving Strategy

- Exploit Analogies or Explore Related Problems.

Find \( q = f(a,b,c) \)
Problem Solving Strategy

- Exploit Analogies or Explore Related Problems.

Find $q = f(a,b,c)$