

PROBLEM SOLVING

Chapter 3

Shahab D. Mohaghegh

West Virginia University

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)

Projected Frontal Area (m^2)

Velocity (m/s)

The diagram shows the equation $F = \frac{1}{2} C_d \rho A v^2$ with four arrows pointing from text labels to the variables in the equation. The label 'Drag Coefficient (dimensionless)' points to C_d . The label 'Air Density (kg/m^3)' points to ρ . The label 'Projected Frontal Area (m^2)' points to A . The label 'Velocity (m/s)' points to v .

Problem Solving Approach

$$F = \frac{1}{2} (0.25) (1.18 \frac{k_g}{m^3})$$

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

$$= 190 N \frac{lb_f}{4.448 N} = 42 lb_f$$

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 PROFESSIONAL
- 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

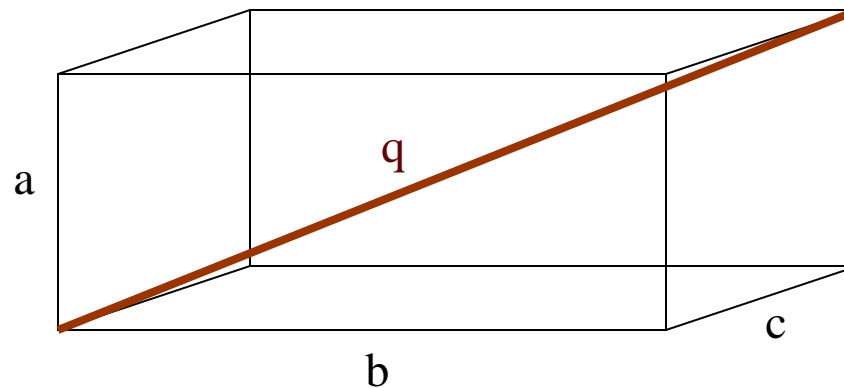
- Prerequisites of creativity
 - Mastering the basics
 - Practice, practice, practice,
- World is full of intellectually brilliant failures.

Problem Solving Strategy

- Understand the problem
- Devise a plan
- Carry out the plan
- Look back

Problem Solving Strategy

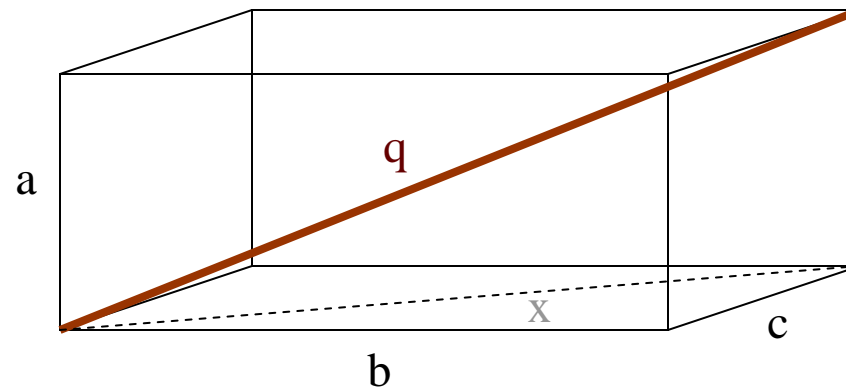
- Exploit Analogies or Explore Related Problems.



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

Problem Solving Strategy

- Exploit Analogies or Explore Related Problems.



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