Creativity and Engineering

• The professional life of engineers is devoted to the creative solution of problems
• Technology is the result of creativity with a purpose, or engineering design

• Sending someone to the moon and to bringing him back to earth in 1968 required a number of technologies created by Engineers
Creative Engineers Have:

- Curiosity and tolerance of unknown
- Openness to new experiences
- Willingness to take risks
- Ability to observe details and see the “whole picture”
- No fear of problems
- Ability to concentrate and focus on the problem until it’s solved
What some once said:

• This 'telephone' has too many shortcomings to be seriously considered as a means of communication. The device is inherently of no value to us. (*Western Union internal memo, 1876*)

• I think there is a world market for maybe five computers. (*Thomas Watson*, 1943)

• 640K [memory] ought to be enough for anybody (*Bill Gates*, 1981)
What you should hear:

• Great spirits have always encountered violent opposition from mediocre minds.
  - Albert Einstein

• The person who says it cannot be done should not interrupt the person doing it.
  - Chinese Proverb

• Every really new idea looks crazy at first.
  - Alfred North Whitehead*
Teams and Creativity

- Teams combine the different backgrounds, experiences and thinking preferences of individuals.

- Interaction among team members – other’s ideas are used as stepping-stones to more creative ideas.

- Willingness on the part of a team to take greater risks.
Engineering Creative Methods

• **Evolution:** Incremental improvement; *Every problem that has been solved can be solved again in a better way.*

• **Synthesis:** Two or more existing ideas are combined into a third, new idea.

• **Revolution:** Completely different, new idea

• **Reapplication:** Look at something old in a new way.

• **Changing Direction:** Attention is shifted from one angle of a problem to another

*Introduction to Creative Thinking*, Robert Harris. Version Date: July 1, 1998
Engineering Creativity and Constraints

• In engineering, creativity is useful only if it fits into the realities of the physical world
  • A creative idea in engineering must conform to the established physical laws
  • A creative idea in engineering must conform to our present knowledge of the nature of matter, unless we invent or find a new form of matter.
• Creativity in engineering is constrained by feasibility and practicality.
Creativity Stimulation Techniques

- Inversion
- Morphological Analysis
- Analogy
- Brainstorming
- Many others
Techniques: Inversion

• Inverting the problem to view it from a different angle
• If you would like to save energy, explore wasting energy

• The crow example: Water too low in the jug. Instead of trying to explore how to go to the water, explore how the water can get to the crow. Solution, put stones!
Techniques: Morphological Analysis

• The problem is divided into smaller sub-problems.
• Concepts are generated to satisfy each smaller problem.
• A four-step process

  1. list the functions and features required
  2. Identify as many ways as possible for each feature or function
  3. Draw a table with functions listed vertically and features or concepts listed horizontally
  4. Identify all practical combinations
Techniques: Morphological Analysis (Example)
Design a means of transportation for disabled persons

| Feature      | Concept 1        | Concept 2      | Concept 3     | Concept 4
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Body Support</td>
<td>armchair</td>
<td>under arm</td>
<td>leg support</td>
<td>sofa</td>
</tr>
<tr>
<td>Ground Support</td>
<td>rollers</td>
<td>tracks</td>
<td>wheels</td>
<td>skids</td>
</tr>
<tr>
<td>Power Supply</td>
<td>Battery</td>
<td>solar</td>
<td>human</td>
<td>air</td>
</tr>
<tr>
<td>Speed Control</td>
<td>automatic</td>
<td>manual</td>
<td>on-off</td>
<td>-</td>
</tr>
<tr>
<td>Direction Control</td>
<td>side thrust</td>
<td>one side lock</td>
<td>reverse</td>
<td>Steering</td>
</tr>
</tbody>
</table>

Design 1: Armchair + Rollers + Solar + Automatic + Side-thrust
Design 2: Armchair + Wheels + Human + Manual + Steering
Morphological Analysis (cont’d)

• This approach is very powerful
• It generates “too many” combinations
• Many obviously will not make sense and can be quickly eliminated
• However, you often find a new idea by looking at the possible combinations of concept pieces
• Remember, this is an iterative process, you may have to go back to square one often
Techniques: Analogy

- **Personal analogy** (imagine yourself in the situation, e.g., if designing a product, imagine yourself as the product itself or one of its functions)
- **Direct analogy** (Copy ideas from nature, wild life)
Techniques: Brainstorming

Rules (within a comfortable/friendly environment):

• Define the problem to be solved
• No criticism allowed during the session
• Large quantity of ideas wanted (quantity over quality)
• Crazy ideas are welcome
• Keep ideas short and snappy
• Combine and improve on others’ ideas “laterally” (new categories) and “vertically” (new ideas in categories)
Idea Selection

• Creative sessions lead to many ideas, how to select the best one?

• Do some clustering first (merge similar ideas under one heading)

• Then, apply one or more of the following options:

  Questions Options Criteria (QOC)
  Voting
  SWOT Analysis
Selection: Questions Options Criteria (QOC)

- Determine important criteria beforehand
- Judge each option (idea) based on the criteria
- Criteria may have a different weighting!

<table>
<thead>
<tr>
<th>Criteria 1</th>
<th>Criteria 2</th>
<th>Criteria 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Option 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Option 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Option 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Option 4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Selection: Voting

• Members are given a fixed number of colored stickers (virtual money)
• Voting for good ideas (criteria) is by putting a sticker next to it
• For very good ideas, multiple stickers can be put
• This could be used to reduce the list of alternative ideas
Selection: SWOT

**Strengths, Weaknesses, Opportunities, Threats**

- Often used to analyze business but can also be used to select ideas
- Specify each of these for each idea
- Can be applied to a reduced list of ideas
- Better suited to modify/improve existing designs
Final Thoughts

• For every good idea, expect to have tens of bad or wrong or useless ideas
• You don’t have to be a mathematical genius. But you should be competent in mathematics.
• Evaluate and improve the extent of your hands-on and laboratory skills.
• Visualize how the work could be accomplished (spread sheets, flow charts, drawing)
• Imagination is also crucial. Begin at the science fiction level, then apply the constraints gradually.
• Keep a design notebook