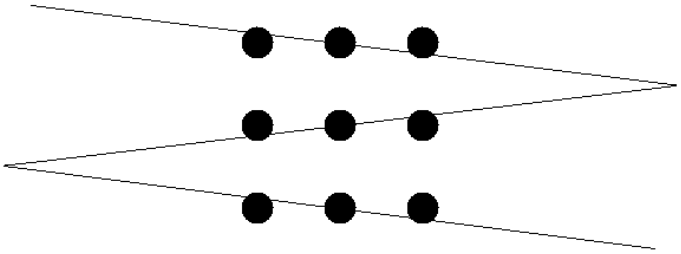
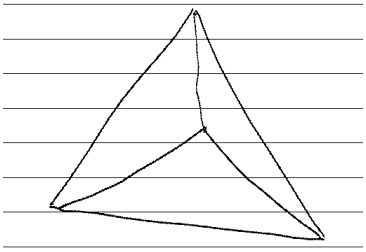
Chapter 4 – Concept Generation and Evaluation

1. **Consider the nine dot puzzle shown in Figure 4.1 (b). Draw three connected straight lines that pass through all nine dots. [A]**

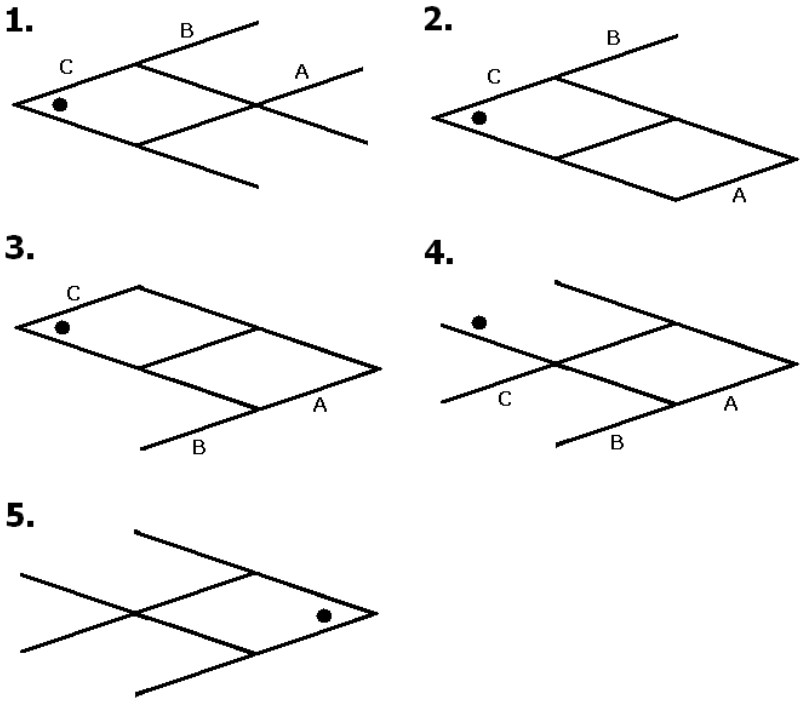


2. **Consider the six sticks shown below. Rearrange the sticks to produce four equilateral triangles (the sticks cannot be broken). [A]**



In this solution, one has to go to 3 dimensions!

3. **Consider the fish shown below made of eight sticks and a coin for the eye. The objective is to make the fish face the other direction by moving only the coin and three sticks. [A]**



4. **For each of the following lateral thinking puzzles, develop a plausible solution (from Paul Sloane's Lateral Thinking Puzzles [http://dspace.dial.pipex.com/sloane]): [A]**

    a. **A man walks into a bar and asks the barman for a glass of water. The barman pulls out a gun and points it at the man. The man says 'Thank you' and walks out.**

    The man had hiccups. The barman recognized this from his speech and drew the gun in order to give him a shock. It worked and cured the hiccups - so the man no longer needed the water.

    b. **A woman had two sons who were born on the same hour of the same day of the same year. But they were not twins. How could this be so?**

    The woman had triplets. They were two of the triple.

    c. **Why is it better to have round manhole covers than square ones?**

    While the square manhole sounds just as plausible as the round manhole cover, there is a major disadvantage. The round manhole cover will never be able to fall down the whole, because the diameter of the cover never changes. The square cover, if in the right position, would be able to be dropped down the hole.

    d. **A man went to a party and drank some of the punch. He then left early. Everyone else at the party who drank the punch subsequently died of poisoning. Why did the man not die?**

    The punch, in its original state, was not poisoned. So, the man that had it early and left drank the punch without the poisoning. However, those that stuck around at the party continued drinking the same punch even after it was poisoned.

5. **Legislation was passed to allow handguns in the cockpits of passenger airlines to prevent hijacking. Brainstorm to develop concepts that prevent anyone other than the pilot from using the handgun. [A]**

    Note: *This is a brainstorming exercise that we have used in our class a number of times with good results. Many interesting solutions will be developed, including those that involve biometric recognition of people to match them with the gun, mechanical solutions, and electronic solutions (i.e. proximity sensor of gun to pilot).*

6. **Imagine if scientists and engineers were able to develop a technology that would allow people to be transported form any place on earth to another instantaneously. Brainstorm to determine the potential impact this would have on society. [A]**

    Brainstorming - no solution provided

7. **Student advising at many colleges and universities is seen as an area that can be improved. Brainstorm to develop ideas as to how student advising could be improved at your college or university. [A]**

Brainstorming - no solution provided

8. **In your own words, describe what a concept table and a concept fan are.**

   A concept table is a methodic method of investigating different combinations, arrangements, and substitutions of technologies for a given design. A concept fan is a hierarchical graphical representation of the design decisions, choices, and alternative solutions. A disadvantage of them is that they assume a form, or architecture, for the solution.

9. **Consider Example 4.1 in the chapter. For this example assume that:**

   - **The following is the result of the paired comparison.**

	Accuracy	Cost	Size	Availability	Sum
Accuracy	-	0	1	0	**1**
Cost	1	-	1	½	**2½**
Size	0	0	-	0	**0**
Availability	1	½	1	-	**2½**

- **The parts costs are the following: resistors = $0.05, bipolar transistors (BJTs) = $0.10, op amps = $0.35, and RTDs = $0.25.**
- **The parts have an in-stock availability of 99%, 90%, 85%, and 70% of the time for the resistors, BJTs, RTDs, and op amps respectively.**
- **Everything else is the same as presented in Example 4.1.**

Compute the rankings of the design options using a weighted decision matrix of the type shown in Table 4.5. [R/A]

Step 1: Determine the Criteria

In this example the comparison criteria of accuracy, cost, size and availability were given as a part of the problem.

Step 2: Select the Weighting Factors

The weighting factors for the criteria are selected based upon the scores from the pair wise comparison. Normalizing the weighing factors as indicated in (2) produces $\boldsymbol{\omega_1 = 1/6 = 0.17}$, $\boldsymbol{\omega_2 = 2.5/6 = 0.42}$, $\boldsymbol{\omega_3 = 0/6} = 0$, $\boldsymbol{\omega_4 = 2.5/6 = 0.42}$.

Step 3: Select the Design Ratings

Design ratings need to be made for each of the criterion.

Accuracy. Since the objective is to minimize the deviation, the following rating is used

$$\alpha = \frac{\min\{\text{deviation}\}}{\text{deviation}}.$$

This produces the following design ratings for accuracy: $\alpha_{11} = 0.14$, $\alpha_{12} = 1.0$, and $\alpha_{13} = 0.68$; and normalizing the row sum produces $\boldsymbol{\alpha_{11} = 0.08}$, $\boldsymbol{\alpha_{12} = 0.55}$, and $\boldsymbol{\alpha_{13} = 0.37}$.

Cost. Using the provided cost measure ($0.40 for design 1, $0.65 for design 2, and $0.50 for design 3) gives the following cost ratings for the three options respectively: $\alpha_{21} = 1.0$, $\alpha_{22} = 0.62$, and $\alpha_{23} = 0.8$. Normalizing the row sum produces $\boldsymbol{\alpha_{21} = 0.41}$, $\boldsymbol{\alpha_{22} = 0.26}$, and $\boldsymbol{\alpha_{23} = 0.33}$.

Size. The objective is to minimize size. Using a measure analogous to the given space to manufacture each produces the following normalized decision ratings: $\boldsymbol{\alpha_{31} = 0.48}$, $\boldsymbol{\alpha_{32} = 0.31}$, and $\boldsymbol{\alpha_{33} = 0.21}$.

Availability. A measure for the overall availability of parts to manufacture each design is required. One way to measure this is to compute the probability that a design will be able to be manufactured based upon the past history of part availability. This is found by multiplying the availability of all individual components needed for the design:

P(design 1 can be produced) = (0.99)(0.85)(0.90) = 0.76

P(design 2 can be produced) = (0.99)(0.85)(0.70) = 0.59

P(design 3 can be produced) = (0.99)(0.85)(0.90)(0.90) = 0.68

This produces the following normalized decision ratings for availability: $\boldsymbol{\alpha_{41} = 0.37}$, $\boldsymbol{\alpha_{42} = 0.29}$, and $\boldsymbol{\alpha_{43} = 0.33}$.

Step 4: Compute the Scores

		Single BJT	Op Amp	Current Mirror
Accuracy	0.17	0.08	0.55	0.37
Cost	0.42	0.41	0.26	0.33
Size	0	0.48	0.31	0.21
Availability	0.42	0.37	0.29	0.33
Score		0.34	0.32	0.34

Step 5: Review the Decision

Remember that this is a semi-quantitative method. The final ranking indicates that design all design options are essentially equal in this case.

10. Project Application. Conduct brainstorming to identify concepts for solving the design problem. Critically evaluate the concepts generated using one of more of the techniques presented in the chapter that is appropriate for the problem. Section4.4 provides guidance on how to conduct this and document the results. [P]

Note: *We usually combine this with the Design project application problem (5.7) in Chapter 5. What we are looking for is for each team to show that they have examined different potential solutions to the design problem and evaluated the alternatives. Thus they can document the results a variety of ways – such as concept fan/table or decision matrix. Highly quantitative decision tables are frankly difficult to develop, and the results may not be that valuable. We try to get them to demonstrate that they have put serious effort into examining the different solutions for a problem. Below is the text from the assignment that is provided to the students*

The team must show that it has analyzed and evaluated different options/concepts for the design. This means that you should have examined different alternatives and be able to justify the choices the team made. The choices could be in terms of different design architectures and/or different decisions for elements of the overall system.

Apply the methods from Chapter 4 that are appropriate for the problem. The results can be presented in terms of a list of brainstormed ideas, Concept Tables/Fans and Decision matrices. If you do use decision matrices, you can use them to benchmark or compare different technical solutions considered. Only use the highly quantitative matrix (i.e. Example 4.1) if it realistic and applicable to the problem.